# CANADIAN MINERALS YEARBOOK 1983-1984

## Review and Outlook

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MINERAL REPORT 33

# CANADIAN MINERALS YEARBOOK 1983-1984

## Review and Outlook

Energy, Mines and
Resources Canada

Minerals

Énergie, Mines et
Ressources Canada

Minéraux

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# Foreword

This issue of the Canadian Minerals Yearbook looks retrospectively at the Canadian mineral industry during 1983 and 1984 and prospectively at the direction the industry is likely to take in the foreseeable future. The present edition is the latest in a series of official documents published under various titles since 1886 when the Government of Canada first reported comprehensively on the country's mineral industry.

The General Review chapter deals with the main events and trends in the Canadian economy over the two years covered in this Yearbook. This section also deals with general developments and overall patterns in the mineral industry over that time. Commodity review sections provide the same type of information as in past issues. Outlook sections, however, have been expanded to place greater emphasis on projections for the future of the industry. With this change, the Yearbook should prove to be a useful tool for a broader audience than in previous years.

The basic statistics on Canadian production, trade and consumption were collected by the Information Systems Division, Mineral Policy Sector, Energy, Mines and Resources Canada, and by Statistics Canada, unless otherwise stated. Company data were obtained directly from company officials through surveys or correspondence or from corporate annual reports. Market quotations are mainly from standard marketing reports.

Additional copies of the Yearbook can be purchased from the Canadian Government Publishing Centre. Reprints of individual chapters and Map 900A, Principal Mineral Areas of Canada, may be obtained free of charge from:

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Energy, Mines and Resources Canada
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Ottawa, Ontario
K1A OE4

Previous editions have been deposited in various libraries.

Energy, Mines and Resources Canada is grateful to all those who contributed information used in compiling this report.

May 13, 1985

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Front Cover:
Geologist studies mineral sample in open-pit mine, Pine Point, N.W.T.
(George Hunter photo)

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Imperial Units to Metric (SI) Units

| | | |
|---|---|---|
| Ounces to grams | x | 28.349 523 |
| Troy ounces to grams | x | 31.103 476 8 |
| to kilograms | x | .031 103 476 |
| Pounds to kilograms | x | .453 592 37 |
| Short tons to tonnes | x | .907 184 74 |
| Gallons to litres | x | 4.546 09 |
| Barrels to cubic metres | x | .158 987 220 |
| Cubic feet to cubic metres | x | .028 346 85 |

Source: Canadian Metric Practice Guide

# General Review

L. LEMAY

## THE ECONOMY IN 1984

1984 was a year of partial economic recovery in Canada. The expectations at the beginning of the year that stable interest rates would shape a strong, robust return to growth did not entirely materialize. The key Bank of Canada rate started the year at 9.96 per cent and forecasters predicted a strong, sector-wide recovery, but by mid-year the Bank rate had climbed considerably. It peaked in July at 13.26 per cent thus stiffling any momentum built up in the economy. Strength in business activity continued into the third quarter of 1984 due mainly to a surge in exports, specifically to the U.S. market, however, it could not be maintained. The economic slowdown in Canada in the fourth quarter mirrored a slowdown in the United States. The United States economy experienced a dramatic increase in the level of growth through most of the year but succumbed to high interest rates in the last quarter.

In Canada, real growth in GNP averaged a modest 3.2 per cent on an annual basis over the first two quarters of 1984, rose in the summer to record a surprisingly strong third quarter performance of 7.6 per cent, but fell back again late in the year. The real rate of growth of GNP for the year is estimated at 4.4 per cent compared with 3.3 per cent for 1983. Inflation, one of the favourable indicators, was under control, finishing the year at less than 5 per cent compared with 6 per cent in 1983. However, the unemployment rate stayed stubbornly above 11 per cent leaving about 1.4 million Canadians out of work.

The foreign trade sector was the brightest aspect of the Canadian economy in 1984. A record merchandise trade surplus of $20 billion was reached, up from the $18 billion of 1983, contributing to an overall surplus on the current account for the third consecutive year. This trade surplus was due to a number of factors including lower world oil prices, an improvement in auto trade with increased United States demand for larger automobiles built in Canada, the relative strength of the U.S. economy and the depreciation of the Canadian dollar against the United States dollar. The Canadian dollar slid from about 80 cents (U.S.) at the beginning of the year to an historic low of 74.86 cents (U.S.) in July. It recovered to above the 76 cent level and hovered there for the rest of the year.

Merchandise exports in Canada reached a record level of $94.5 billion in the first ten months of 1984, 76 per cent of which were destined for the United States. Canada's trade surplus with the United States grew to almost $20 billion in 1984 from less than $500 million in 1979. At the same time, the surplus with the rest of the world shrank to almost zero from about $400 million.

This growth in exports was the stimulating factor for production increases in export-oriented industries such as motor vehicles and parts, pulp and paper, sawmills and crude minerals and products including nickel, copper, iron ore, coal and some nonmetallic minerals.

## THE MINERAL INDUSTRY IN 1984

The Canadian mineral industry in 1984 continued to be tested as it had been throughout the 1980s by a combination of circumstances that had shaken the industry to its foundation. The road to recovery has been longer and harder than anticipated and profits in 1984 for many mining companies remained elusive. Net income for the industry (excluding energy) totalled $210 million in the first half of the year, a 96 per cent improvement over 1983 but nowhere near pre-recession levels. Despite predictions of improvement, mineral commodity prices remained generally weak on world markets and demand continued to be sluggish. The industry benefited strongly from the lower Canadian dollar, with 80 per cent of its output destined for export. One industry spokesman was quoted as saying "If

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the Canadian dollar were at par with the United States dollar, the mining industry in Canada would be virtually bankrupt."

Mineral industry output showed a healthy increase in 1984 compared with 1983. Value of output reached $43.1 billion, up from 38.5 billion the previous year. All sectors of the industry, including metallics, nonmetallics, structural materials and fuels recorded significant increases with the greatest improvement coming from the metallic and nonmetallic mineral sectors.

**Canadian Mineral Production**
**1983 and 1984**

| | 1983 | 1984 | % Change 1984/1983 |
|---|---|---|---|
| | (millions of current dollars) | | |
| Metals | 7.4 | 8.5 | +14.9 |
| Nonmetals | 1.9 | 2.3 | +21.1 |
| Structurals | 1.8 | 1.9 | + 5.5 |
| Fuels | 27.2 | 30.0 | +10.3 |
| Total | 38.5 | 43.1 | +12.0 |

On a commodity basis, the ten leading minerals in 1984 were: crude petroleum, natural gas, natural gas byproducts, coal, iron ore, zinc, copper, gold, nickel and uranium. These ten minerals represented 87 per cent of the total value of output of the industry and all except copper, gold and silver showed increases over the previous year.

On a regional basis, Alberta represented the largest share of output in Canada, reaching 60 per cent of the total or $26 billion in 1984, up from $24.1 billion in 1983. Ontario followed with 10 per cent of the total at $4.5 billion. Output was up slightly in British Columbia, totalling $3.4 billion while, Quebec, seriously affected by the continued weak demand for iron ore and asbestos remained unchanged, at $2.0 billion. With the reopening of some mining operations in the Northwest Territories during the year, value of output there showed the largest proportionate increase moving from $595 million in 1983 to $738 million in 1984.

## MINERAL INDUSTRY PRICES

Soft prices for several key commodities such as copper, molybdenum, nickel, iron ore, gold and silver kept the recovery of the industry at a slower pace than expected. An increase in the volume of copper output of 9.1 per cent in 1984 over 1983 was not matched by an increase in value. After averaging 94.8 cents (Cdn.) per pound (76.9 cents U.S.) in 1983, the price of copper dropped to an average of 86.1 cents (66.5 cents U.S.) per pound in 1984. Once again, shutdowns were prevalent in the North American industry and idle capacity of approximately 1 million t of copper existed around the world. Molybdenum showed some improvement in 1984 with value of production up 24.1 per cent but prices remained weak. At about $US 3.30 per pound the price was below the cost of production at all Canadian mines.

Demand for nickel increased with an upturn in demand in the steel sector in 1984, but overcapacity still existed, preventing any significant increase in price. Nickel is now produced in over 25 countries, up from three in 1950, and state ownership of the industry has increased from 15 per cent to 40 per cent over the same period.

In the international iron ore market, prices were at record lows during the year, well below the Quebec-Labrador average production cost. Since the recession, Quebec-Labrador has not been working at much more than 50 per cent of capacity and little improvement is seen in the next few years because of world over-capacity compounded by new projects coming on-stream in Australia, Brazil and West Africa.

The price of gold tumbled throughout 1984. It reached its lowest point since June 1982 late in December, and threatened to fall below $US 300 per ounce at year-end. It averaged $US 362.68 on the LME ($Cdn 469.65) in 1984 compared with $422.60 ($Cdn $520.79) in 1983. Losing its appeal as a hedge against inflation, the price of gold has been depressed by the strength of the U.S. dollar, reduced concerns about inflation and falling commodity prices in general.

Silver suffered from an increasing glut of supply in the western world along with stagnating, even falling demand, and the price averaged $Cdn 10.87 in 1984 compared with $14.15 in 1983. Uranium prices fell to $US 17.50 per pound in 1984 from $20 in 1983, well below the late-1970s price of $34, principally due to oversupply of the commodity.

Zinc was in a more stable supply balance in 1984 and prices improved steadily from mid-1983 through most of 1984 reaching a 10-year high of 67.5 cents (Cdn.) in June. Increased demand by automobile manufacturers kept stocks down and prices averaged 63.8 cents (Cdn.) in 1984, up from 52.1 cents in 1983 and 48.7 cents in 1982. Aluminum started the year, also on a high note. Encouraged by relatively high prices in 1983, idle capacity was brought on-stream in early-1984. However, the anticipated increase in demand failed to materialize. Supply continued to rise until mid-1984 pushing prices down and world stocks of aluminum ended the year about 25 per cent above normal. A major structural change in the world aluminum market occurred late in the year with the acknowledgement by Alcan Aluminum Ltd. of Montreal, the largest producer, that its world list price was no longer the reference point. Prices are now set mainly in major commodity markets such as the LME.

Downward pressure on prices existed for nonmetallic minerals in 1984 as well. Many major nonmetallics remained in oversupply. Shipments of asbestos for example were down to 836 000 t from 858 000 t a year earlier and a long way from the peak year of 1973 when Canada exported a record 1.7 million t. New producers such as Brazil, Colombia and Greece are entering the market making it increasingly difficult for Canada to maintain its 30 per cent share of western world markets.

## MINERAL TRADE AND INVESTMENT

While mineral production increased moderately in 1984, mineral exports contributed greatly to the strong Canadian surplus in overall merchandise trade. In the first nine months, exports of crude and fabricated minerals totalled $21.6 billion, a 20 per cent increase over the same period of 1983. Crude nonferrous mineral exports were up 27.6 per cent over 1983 while crude nonmetallics showed a 35.4 per cent increase. Fabricated mineral exports totalled $9.7 billion in the first nine months of 1984 up from $7.9 billion in 1983. Crude and fabricated minerals represented 27 per cent of total domestic exports in 1984, 75 per cent of which went to the United States, 9 per cent to Japan, 3 per cent to the United Kingdom and 5 per cent to the rest of the EEC.

Mineral industry imports totalled $10.1 billion in the first nine months of 1984 up from $8.2 billion in 1983. Fifty-seven per cent of total mineral imports came from the United States and if mineral fuels were excluded that percentage would increase to 71 per cent of the total.

Investment in the mineral industry in 1984 presented a brighter picture after two years of cutbacks and cost-saving measures. New capital expenditure intentions totalled $10.2 billion in 1984 for mines, quarries and oil wells up from $9.6 billion in 1983 and $9.4 billion in 1982. When repair expenditures were included that total reached $13 billion in 1984. The greatest improvement in new capital spending came from the metal mining sector. After declining 23 per cent in 1982 from a level of $2.0 billion in 1981, spending declined a further 26 per cent in 1983 reaching only $1.1 billion. In 1984, it had recovered to a level of $1.4 billion. Nonmetal mining showed a strong increase as well from a level of $322.4 million in 1983 to $477.7 million in 1984. Coal mining, on the other hand showed a sharp decline in 1984 dropping almost 65 per cent from $1.1 billion in 1983 to $395 million in 1984. Exploration activity in Ontario was up for the third consecutive year particularly in the Hemlo area. One spokesman was quoted as saying "A trip to Hemlo these days is like a tonic to dispel the blues brought on by mining's current state of depression". Four new gold mines started up in Ontario in the first half of 1984. Gold fever filtered into Quebec as well and all the way to the Yukon where the Wheaton River Valley was providing some excitement.

The Saskatchewan Mining Development Corporation (SMDC) discovered what is expected to be the richest uranium deposit in the world at Cigar Lake, about 15 km north of Key Lake. The uranium grade is estimated to be 10 per cent, four times that of Key Lake, previously believed to be the world's richest discovered deposit.

## OUTLOOK

The economic outlook for 1985 calls for more moderate growth both in Canada and the United States. Once again, interest rates will be the determining factor. If measures in the United States aimed at reducing the federal deficit are successful, and as a result, interest rates fall, Canadian rates will follow thus providing business with the incentive to invest and stimulate economic activity. The continued strength of the U.S. dollar has had a negative effect on metal prices and it may be, that with a weakening in this currency, demand for metals and their prices will rise. The Canadian dollar is expected to stay firm, strengthening from 76 cents (U.S.) to an average of 78 cents for the next few years. The basis for the improvement is the record trade surpluses and an improved inflation rate. However, in order for the mineral industry to take advantage of increased trade potential it will have to contend with the structural changes and adjustments taking place throughout the world. Changing patterns in metal consumption brought on by energy conservation policies as well as technological innovations have severely affected the growth in demand for minerals. At the same time, growing foreign competition, much of it from government-controlled producers have cut into traditional market shares once taken for granted by Canadian and United States producers. Global overcapacity has existed for most metals throughout the 1980s. The situation continues to be exacerbated by debt-ridden Third World countries forced to maintain production of minerals to earn foreign exchange. Continuous currency devaluations in Third World countries have been carried out, thus improving their competitive edge. As a result, investment, the key to economic growth has not been forthcoming in the North American mineral industry.

Due to the severity of the 1981-82 recession, cost reduction has become the main goal of most businesses. The Canadian mining industry has been largely successful in this goal making major productivity gains in 1983 and 1984, through improved mining methods, as well as labour force reductions. Tighter inventory controls and increased throughput have also brought lower costs. However, some of these reduction measures can only be maintained in the short-term. These measures along with curtailment in development at existing and new mining sites increase the lead time required to respond to a change in demand by an increasing rate. Massive capital expenditures will be necessary for most companies to reach increased production targets. The full effect of mine closures will be felt especially for copper in the next 12 to 18 months and producers will have to react to an anticipated increase in demand. In the meantime, emphasis should be placed on product development and diversification. There is room for growth in new applications for mineral products in construction, and automobile manufacturers. Increased consumption in copper, aluminum and zinc is very possible in these sectors.

With a continued improvement in cost competitiveness, the next step for Canadian mining companies is a more aggressive marketing strategy to increase market access for Canadian mineral exports. The characteristics that have made Canada the second largest mineral exporter in the world still exist. The broad range of minerals, the stable political envirionment and the well-developed economic and social infrastructure are still very much in place. The challenge will be to respond quickly and effectively to the anticipated turnaround in mineral demand.

## CANADA, PRODUCTION OF LEADING MINERALS, 1983 AND 1984

| | 1983 | 1984 | % change 1984/1983 | 1983 | 1984 | % change 1984/1983 |
|---|---|---|---|---|---|---|
| | (000 tonnes except where noted) | | | ($ millions) | | |
| **Metals** | | | | | | |
| Copper | 653.0 | 712.4 | +9.1 | 1,364.4 | 1,351.4 | -1.0 |
| Gold (kg) | 73.5 | 81.3 | +10.6 | 1,230.9 | 1,227.8 | -0.3 |
| Iron ore | 32 959.0 | 41 065.0 | +24.6 | 1,269.9 | 1,470.9 | +15.8 |
| Lead | 272.0 | 259.4 | -4.6 | 160.5 | 190.8 | +18.9 |
| Molybdenum (t) | 10 194.0 | 10 865.0 | +6.6 | 87.7 | 108.9 | +24.1 |
| Nickel | 125.0 | 174.2 | +39.4 | 781.5 | 1,165.2 | +49.1 |
| Silver (t) | 1 197.0 | 1 171.0 | -2.2 | 544.7 | 409.3 | -24.9 |
| Uranium (U) | 6 823.0 | 9 693.0 | +42.1 | 667.7 | 916.3 | +37.2 |
| Zinc | 987.7 | 1 022.1 | +3.5 | 1,135.2 | 1,438.0 | +26.7 |
| **Nonmetals** | | | | | | |
| Asbestos | 858.0 | 836.0 | -2.6 | 391.3 | 413.0 | +5.5 |
| Gypsum | 7 507.0 | 8 725.0 | +16.2 | 59.3 | 69.2 | +16.7 |
| Potash ($K_2O$) | 6 294.0 | 6 972.0 | +10.8 | 645.8 | 759.3 | +17.6 |
| Salt | 8 602.0 | 10 294.0 | +19.7 | 172.8 | 214.9 | +24.4 |
| Cement | 7 871.0 | 8 619.0 | +9.5 | 606.1 | 667.1 | +10.1 |
| Clay Products | .. | .. | .. | 132.3 | 140.9 | +6.5 |
| Lime | 2 232.0 | 2 280.0 | +2.2 | 156.7 | 174.5 | +11.4 |
| **Fuels** | | | | | | |
| Coal | 44 787.0 | 56 800.0 | +26.8 | 1,303.9 | 1,814.0 | +39.1 |
| Natural gas (000 $m^3$) | 72 229 000.0 | 73 656 000.0 | 2.0 | 7,077.2 | 7,514.6 | +6.2 |
| Petroleum (000 $m^3$) | 78 751.0 | 82 989.0 | 5.4 | 16,091.8 | 17,887.8 | +11.2 |

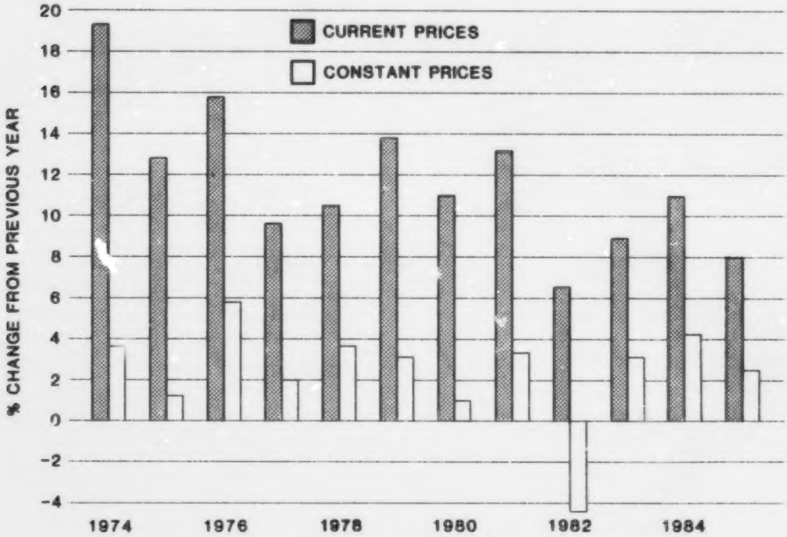
.. Not available.

## CANADA, EXPORTS OF MINERALS, CRUDE AND FABRICATED

|  | Year 1973 | Year 1978 | Year 1983 | 1st 9 months 1983 | 1st 9 months 1984 | % Changes 1st 9 months 1984 / 1st 9 months 1983 |
|---|---|---|---|---|---|---|
|  | ($ millions) |  |  |  |  |  |
| Crude |  |  |  |  |  |  |
| Ferrous | 497.7 | 854.5 | 1,054.3 | 787.5 | 890.9 | +13.1 |
| Nonferrous | 1,501.8 | 1,549.2 | 1,845.9 | 1,304.9 | 1,664.4 | +27.6 |
| Nonmetallic | 595.5 | 1,369.7 | 2,103.5 | 1,468.2 | 1,987.6 | +35.4 |
| Fuels | 1,998.4 | 4,514.8 | 8,727.9 | 6,573.2 | 7,358.2 | +11.9 |
| Total | 4,593.4 | 8,288.2 | 13,731.6 | 10,133.8 | 11,901.1 | +17.4 |
| Fabricated |  |  |  |  |  |  |
| Ferrous | 598.7 | 1,696.1 | 2,011.6 | 1,445.0 | 1,964.2 | +35.9 |
| Nonferrous | 1,897.8 | 3,360.9 | 5,624.6 | 4,009.0 | 5,048.3 | +25.9 |
| Nonmetallic | 166.2 | 377.1 | 424.8 | 315.9 | 400.1 | +26.7 |
| Fuels | 311.6 | 1,022.7 | 2,815.6 | 2,109.8 | 2,303.8 | +9.2 |
| Total | 2,974.3 | 6,456.8 | 10,876.6 | 7,879.7 | 9,716.4 | +23.3 |
| Total crude and fabricated minerals |  |  |  |  |  |  |
| Ferrous | 1,096.4 | 2,550.6 | 3,065.9 | 2,232.5 | 2,855.1 | +27.9 |
| Nonferrous | 3,399.6 | 4,910.1 | 7,470.5 | 5,313.9 | 6,712.7 | +26.3 |
| Nonmetallic | 761.7 | 1,746.8 | 2,528.3 | 1,784.1 | 2,387.7 | +33.8 |
| Fuels | 2,310.0 | 5,537.5 | 11,543.5 | 8,683.0 | 9,662.0 | +11.3 |
| Total | 7,567.7 | 14,745.0 | 24,608.2 | 18,013.5 | 21,617.5 | +20.0 |
| Total domestic exports all products | 24,837.9 | 52,259.3 | 88,506.2 | 63,882.3 | 81,439.9 | +27.5 |
| Crude minerals as % of exports, all products | 18.5 | 15.9 | 15.5 | 15.9 | 14.6 |  |
| Crude and fabricated minerals as % of exports, all products | 30.5 | 28.2 | 27.8 | 28.2 | 26.5 |  |
| Crude mineral exports as % of mineral exports | 60.7 | 56.2 | 55.8 | 56.3 | 55.1 |  |

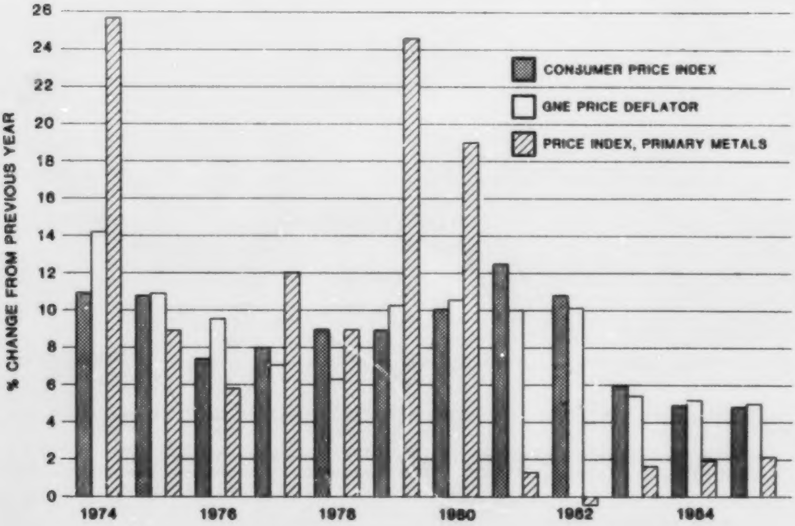
Source: Statistics Canada.

## TRENDS IN CANADIAN ECONOMIC ACTIVITY
(% CHANGE IN GROSS NATIONAL PRODUCT)



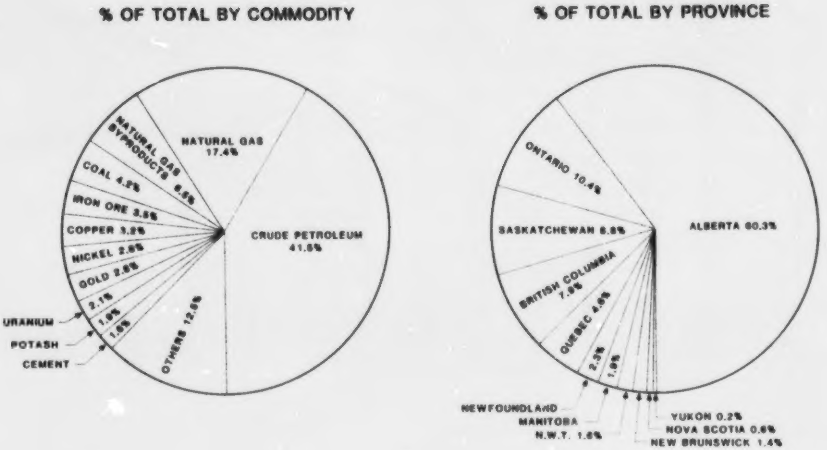
Note: Figures for 1984 and 1985 are estimates

## GENERAL CANADIAN PRICE TRENDS

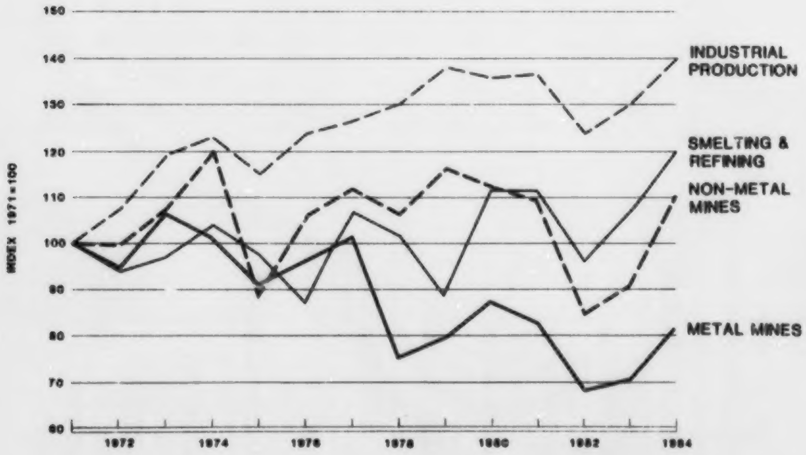


Note: Figures for 1984 and 1985 are estimates

## CANADA, MINERAL PRODUCTION, 1984

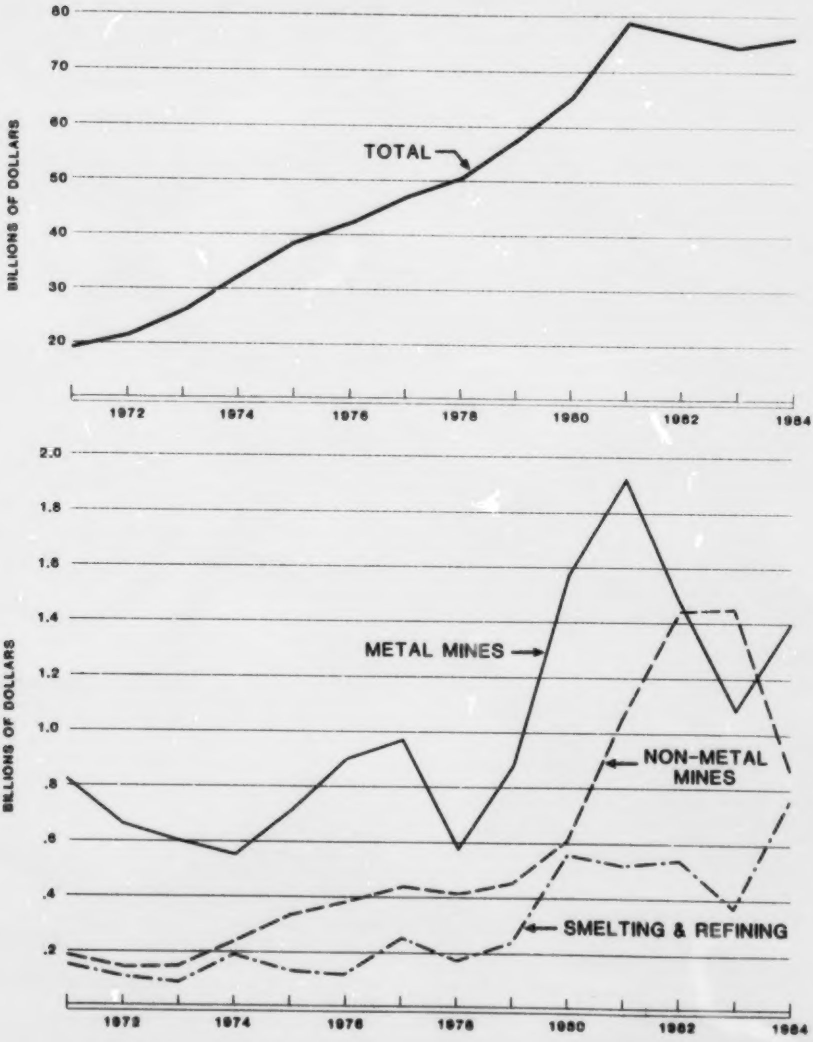


## INDEXES OF GROSS DOMESTIC PRODUCT IN 1971 PRICES



SOURCE : STATISTICS CANADA

# INVESTMENT* IN THE CANADIAN ECONOMY



* CAPITAL EXPENDITURES ON MACHINERY & EQUIPMENT & CONSTRUCTION

SOURCE : STATISTICS CANADA

# International Review

BRUCE A. McKEAN

Supply and demand elements are the touchstones of industry planning. A great deal of time and money is spent trying to predict their relative strengths so as to direct company resources to market opportunities. For minerals, there exist a number of international institutions and negotiating processes which can affect supply and demand or the expectations surrounding them. Almost all of these institutions are concerned in some way with questions of access (that is, access in its broadest sense including market transparency, tariff barriers, government procurement policies, quotas, countertrade requirements, nonconvertable currencies, etc.). Thus, they affect the environment in which future investment in mineral production and processing will occur. Not all of them make positive contributions. Nonetheless, they are important to Canada in view of our dependence on export markets and because access is more and more a vital determinant in whether a sale will be made somewhere other than on a commodity exchange.

Canadian mineral producers have to cope with established (eg. EEC, EFTA, Comecon) and emerging (Caribbean, Latin American) regional trading blocs, preferential tariffs and quotas for LDC (Less Developed Country) producers (eg. the GSP and the EEC Sysmin arrangement with the Lomé Convention countries), increasingly restrictive non-tariff barriers (including those related to the environment and health), the continuing phenomenon of tariffs escalating as value added increases, and the often very high tariff barriers of the newly industrialized countries (NIC's) and LDC's.

It is clear that government (and, increasingly, industry) must use these sometimes little known institutions and occasions to advance or defend Canadian interests. What follows is a review of the major issues and institutions, and what the Canadian mineral industry might expect from them in the near future.

## CANADA/UNITED STATES FREE TRADE PROSPECTS

Periodic talks have been held with the United States since the release of Canada's Trade Policy Review in 1983. The talks have centred on the prospects for a new or revised trade regime between the two countries, i.e., covering almost three-quarters of Canada's total exports and some 50 per cent of our mineral and metal exports. In November, 1984, Canada's Minister for International Trade outlined four possible approaches:

a) a trade enhancement arrangement whereby the present trade regime is maintained but with certain shortcomings overcome;
b) an arrangement whereby the two sides liberalize and improve specific measures such as government procurement practices and emergency safeguards;
c) sectoral free trade wherein products in carefully defined sectors are traded free of all barriers; or
d) a comprehensive trade agreement which would provide for the removal of tariffs and other barriers on essentially all bilateral trade.

It is too soon to speculate on which approach, if any, may prove feasible.

Canada's mineral industry has suggested the negotiation of sectoral free trade for nonferrous metals. However, it remains unclear whether a sectoral approach might gain broad acceptance or how a "nonferrous" metal sector might be defined so as to provide for a balance of advantage for the two countries.

## GENERAL AGREEMENT ON TARIFFS AND TRADE (GATT)

There is an emerging consensus in favour of a new round of multilateral trade negotiations (MTN) under GATT. This has been pushed

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particularly by the United States. These negotiations, which could be formally approved in 1985 and get under way in 1986 or 1987, will provide an opportunity to reduce trade barriers, tighten discipline on the use of non-tariff barriers, and facilitate industrial adjustment.

It was in anticipation of such a new MTN round that world trade ministers met in Geneva in November, 1982. There they drew up a work program for the GATT which included the creation of a working party on natural resource products, specifically in fisheries, forestry and nonferrous metals. The Canadian objective in this exercise is to ensure that all barriers impinging upon trade in these products are identified and their effects described. Of interest to the Canadian mining industry are the three studies on copper, lead and zinc completed in 1984, and the two scheduled for completion in 1985 (aluminum and nickel).

## GENERAL SYSTEM OF PREFERENCES

In June 1971, members of the GATT approved a waiver of the "most favoured nation" (MFN) principle of the GATT and thus provided a legal basis for developed countries to grant preferential market access for developing countries. This has become known as the General System of Preferences (GSP). In 1984 most developed countries extended the original 10-year trial period for an additional ten years. Some countries have expanded the range of products or sizes of quotas under the GSP.

The GSP was a product of the worldwide recognition of the importance to developing countries of improved market access for their labour intensive products. Although trade statistics show OECD imports from LDC's increasing at an annual rate of 27 per cent between 1976-1980, developing countries have not been impressed by the operation of GSP schemes. In fact, experience to date in capital intensive industries such as nonferrous metal smelting and refining suggests that liberalized trade on an MFN basis would be the best objective for all raw material exporting countries. Canada supports this view.

## THE UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT (UNCTAD)

The UNCTAD will be entering its twenty-first year of existence with a new Secretary-General, rumors of an internal reform movement, and suffering from varying degrees of disenchantment from both developed and developing countries. The depth of the problem can be seen when a comparison is made between the aspirations of the institution and its modest accomplishments over the last decade. It is not clear, and the next year will probably not tell, whether the UNCTAD will continue, halt or reverse its slide in political credibility and economic relevance. The momentum, however, remains negative.

## PROCESSING, MARKETING AND DISTRIBUTION

There are a number of issues active in UNCTAD and 1985 may well be known as the year of PMD (Processing, Marketing and Distribution). The label PMD embodies a political undertaking six years ago to agree on a "framework" agreement in support of further processing goals of developing countries. At issue is the appropriateness and direction of intergovernmental action to promote such increased involvement by developing countries.

The developed countries, including Canada, have indicated a preparedness to accept a set of principles and guidelines which would allow developing countries to increase their participation in PMD over time and on economically viable terms. The latest UNCTAD documents contain many proposals which go beyond guidelines and principles. If accepted, they would, inter alia, require the "redeployment" of resource processing industries away from developed countries, the introduction of new discriminatory (in favour of developing countries) trade obligations for developed countries, the creation of a number of new international institutions, and an increase in concessional financing resources.

The initial impression is that the two sides are too far apart for anything to be achieved. The next year may confirm this. This in turn may set the stage for the later negotiation of an agreement which will allow the developing countries to use a fair and open international trading environment to realize, where it exists, the fruits of comparative economic advantage.

## GLOBAL SYSTEM OF TRADE PREFERENCES

At the same time, there are other issues where either the political moment has not arrived or where the concept is still in the process of forming. An example of the latter is known as the Global System of Trade Preferences (GSTP). The LDC's are aware of the importance of international trade, of their own high tariffs, and of a feeling of solidarity over their common economic predicament. The thought is that the LDC's could increase their external trade while preserving their high tariffs against competition from developed countries if - between themselves only - they applied a formula of tariff cuts.

Preliminary economic analysis done by the OECD suggests that western trade with LDC's might drop slightly and inter-LDC trade might increase modestly. A net small increase in total international trade is forecast. This sounds promising but there remain immense political, legal and administrative hurdles ahead for the LDC's. It is possible also that, within the initial macroeconomic figures, there may be some developed countries which stand to loose more than others. Canada will, in future years, want to pay close attention to the GSTP's progress.

## COMPENSATORY FINANCING

While the GSTP is an issue of the future, compensatory financing may receive considerable attention in 1985/86. The report of an Expert Group will be received by the UNCTAD early in the new year. The Group was to tackle the question of whether there is a need for an additional financial facility to compensate developing countries for shortfalls in individual commodity export earnings and, if so, what form, terms, conditions and funding should be brought to such a new facility.

The views of the developed and developing countries differ greatly. The extremes go from a continued reliance on the Compensatory Financing Facility of the IMF to assist with short-term balance of payments problems, to a new financial institution funded with $US 10 billion of new money to cover export earnings shortfalls as they occur in each commodity sector. The Expert Group (with the exception of the U.S.S.R. which will submit a minority report) is reported to have been able to achieve an internal consensus on the issue. It is likely, however, that the report will not be able to command universal support. There will probably occur a lively debate, driven by different economic and ideological interpretations of the problems faced by exporters of commodities. The prospects of an early conclusion, or of a conclusion inimical to Canadian mineral interests, is not high.

## COMMON FUND FOR COMMODITIES

The Common Fund was to assist in the financing of the buffer stock operations of International Commodity Agreements. The negotiations were long (1976-1980) and arduous. The Preparatory Commission which was to set up the institution and set out how and under what conditions the Common Fund should operate, met frequently between 1980 and 1982. What emerged during this latter period were the still unresolved major areas of dispute which, in the negotiations, had been avoided through the use of generalities.

The uncertainty as to the shape and resources of the Common Fund, and the spectacular lack of success in forming new International Commodity Agreements along the lines of the International Tin Agreement, may explain the painful slowness of the ratification process, especially among LDC's. More than four years after the signing of the agreement establishing the Common Fund, neither of the two benchmarks which would bring it into operation had been achieved: 90 states ratifying and a minimum of two-thirds of the capital being represented among the ratifying states.

This year may see a modest revival in activity surrounding the Common Fund as the number of ratifications will probably exceed 100. This is no sign yet, however, that the Preparatory Commission will resume it's work.

## LAW OF THE SEA

As with the Common Fund, the United Nations Convention on the Law of the Sea has been negotiated. In this case, however, a Preparatory Commission is engaged in the lengthy process of developing rules for the exploration and exploitation of the deep seabed. It is also considering the question of overlapping claims among explorers for manganese nodules, specifically the state companies of France, Japan, India, and the U.S.S.R. The four existing private consortia are not involved. These have all received exploration licences under the national legislation of the United States.

The Convention closed for signature on December 9, 1984, and the United States, Federal Republic of Germany and the United

Kingdom had not signed by that date. Consideration of ratification will probably be delayed by many states (including Canada), until the results of the Preparatory Commission's work can be evaluated. The work and the evaluation will take some time.

### INTERGOVERNMENTAL NICKEL DISCUSSION GROUP (INDG)

Last year saw the international emergence of the INDG proposal after five years of mainly Canadian and Australian work behind the scenes. The motivation behind the INDG is found in the profound structural changes occuring in the mineral industry and the presence of many new entrants in the nickel industry. Reliable information for companies and states upon which they can make rational investment decisions is vital if long-term stability is to be achievable. To this end, the October 1984, meeting of 31 countries with an interest in the production, consumption or trade in nickel was highly successful. This will be followed in 1985 by at least one negotiating session.

It is too early to predict success as there remain very real problems concerning the ability and willingness of a number of states to meet the minimum information gathering requirements of the INDG. The possibility of political considerations being interjected still remains, however.

### COPPER STUDY GROUP

The difficult years being experienced by the copper industry - and the sometimes dramatic events such as the Section 201 action in the United States which have marked this period - have revived interest in a copper study group. There is a general acceptance that the International Lead and Zinc Study Group (ILZSG) has proven to be an efficient way to gather and share information. For reasons noted above, negotiations for a nickel discussion group along the lines of the ILZSG have been launched with reasonable prospects for success. Now, some elements of the Canadian copper industry are speaking in favour of a similar group for copper. This may lead to discussions in various international fora but at this time no formal examination of the prospects for such a group is planned.

### INTEGRATED PROGRAM FOR COMMODITIES (IPC): IRON ORE AND MANGANESE

It was the IPC in the UNCTAD and the prospect of many new International Commodity Agreements with economic provisions (including buffer stocks and price undertakings) that prompted a very intensive period of international negotiations in the mid and late 1970s. Very little came of all this effort as political and economic realities clashed with too-high but strongly held expectations on the part of LDC's. The IPC remains in existance, however, and from time to time the water is tested to see if the positions of various players have changed. There was a meeting on iron ore in 1984 and there will be a meeting on manganese and perhaps iron ore in 1985. Nothing of consequence is anticipated from these meetings.

# Regional Review

S. HAMILTON/G. CLEMENTS

Activity in the Canadian mineral industry during 1983 and 1984 was moderate. Mining companies took strong measures to reduce costs to survive. British Columbia, Yukon and Quebec were particularly hard hit by mine closures. Base-metal, asbestos and iron ore mines were particularly vulnerable. New mine developments have been few and have been mainly limited to coal and gold. The export market for coal is becoming increasingly competitive, forcing Canadian producers to accept contracts calling for lower prices and shipments. Precious metal prices have not improved as anticipated andmarginal producers are exhibiting some signs of distress.

Federal-provincial relations in 1983 and 1984 focused on negotiating 10-year Economic and Regional Development Agreements (ERDA's), which identified priorities and strategies for cooperative development. The first ERDA was signed, with Manitoba, in November 1983, and ERDA's with all provinces were in place by the end of 1984.

Mineral development was identified as a priority in several ERDA's, and by mid-1984 Mineral Development Agreements (MDA's) had been signed with Newfoundland, Nova Scotia, New Brunswick, Manitoba and Saskatchewan Discussions with other provinces are continuing.

All MDA's encompass work to provide: geoscience data to stimulate mineral exploration; mining and processing technology to improve productivity and safety in mining operations; and, the identification of new development opportunities by means of market and economic studies. The total federal commitment for the five MDA's is $64.5 million, and the provincial commitments are $38 million.

## NEWFOUNDLAND

The mineral industry is important to Newfoundland, where it accounts for about 10 per cent of the Gross Provincial Product. In 1984, the value of mineral production increased by 23.1 per cent to $993 million from 1983, of which $868 million was for iron ore, $56 million for zinc, and $23 million for asbestos.

Almost all of Newfoundland's mineral commodities are exported, and thus the industry has been severely affected by recent world recession. Weakness in iron ore demand will continue to adversely affect Newfoundland's producers as will low-cost competitors, especially those from Brazil which will have an increasing effect in the latter part of the 1980s.

The closure by Iron Ore Company of Canada (IOC) of its Schefferville, Quebec operation has adversely affected Newfoundland to the present that about 2.5 million tpy of iron ore were mined from deposits that extended into Labrador.

Base metal output has declined sharply over recent years. ASARCO Incorporated's Buchans unit was finally closed in August 1984, although a small, nearby copper deposit is to be tested before the mill is dismantled. Another property, owned by Newfoundland Zinc Mines Limited, continues to produce. Ore reserves are not extensive, but the company is actively exploring for more.

The seasonal recovery and shipment of barite from tailings at the Buchans mine continues. However, production is costly making it difficult to match overseas competition.

Transpacific Asbestos Inc. is shipping asbestos fibre from the Advocate mine at a reduced rate because of weak demand.

The former fluorspar mine at St. Lawrence, closed since 1966, reverted to the Crown in 1983. A new operator, Minworth Ltd. of Britain, has obtained $4.76 million from the federal government and $2.04

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million from the province; thus the company plans to reopen the mine in 1986.

BP Canada Inc. has discovered significant gold mineralization, on a property known as the Chetwynd deposit, in western Newfoundland. The company intends to mount a $2.5 million delineation program in 1985. This discovery indicates that the volcanic and sedimentary rocks of the Hermitage Flexure contain mineralization that had not been previously recognized.

A five-year, $22 million Canada-Newfoundland Mineral Development Agreement was signed in May 1984; 70 per cent will be contributed by the federal government and 30 per cent by the province. During the 1984 field season, geological mapping was conducted in Labrador, and on the Island, geophysical and geochemical surveys were completed. Projects concerning mining and mineral technology and economic development are being planned. This MDA continues the federal-provincial cooperation that started in the late-1960s. Since then, geological mapping and geochemical surveys, in conjunction with changes in land tenure, have been responsible for expenditures of tens of millions of dollars by the private sector on exploration and have led to the discovery of several promising mineral deposits. For example, IOC discovered the Strange Lake beryllium-yttrium rare earth deposit, north of Schefferville, while investigating an anomaly identified by an MDA-funded geochemical survey. The Chetwynd gold discovery is in an area mapped under the MDA where a provincial geologist reported discovering gold mineralization.

## NOVA SCOTIA

In 1984, the value of mineral production in Nova Scotia increased by 12.6 per cent from 1983 to $293 million, of which $163 million was for coal and $44 million for gypsum.

In April 1984, an underground fire at the No. 26 colliery at Glace Bay forced the closure of the mine putting 1,200 employees out of work in an area where unemployment is already high.

The federal government announced a plan to restructure coal mining in Cape Breton in May 1984, which includes the expenditure of $325 million to expand existing mines and develop new ones. Three mines are planned to be replaced. In addition, the federal government plans to spend $2 million to study the feasibility of opening the 1B colliery which has been closed for about 30 years.

Rio Algom Limited began developing a tin mine near Yarmouth in the spring of 1984. It is expected to be in production by late 1985, employing an estimated 250 people. Development was facilitated by a change in provincial royalty legislation that will allow accelerated depreciation of new mines for the purposes of taxation.

Mineral exploration in the province was generally at low levels during 1984. Activity focused on the search for gold, tin, tungsten and barite.

Land use planning maps are being compiled to assist in the formulation of policies called for in the provincial planning act that was instituted in mid-1983.

The Canada-Nova Scotia Mineral Development Agreement was signed in June 1984, continuing and expanding work conducted under a two-year agreement which expired March 31, 1984. Under this new agreement, $16.1 million federal and $10.8 million provincial funds will be invested over five years by the parties in coordinated programs. Geoscientific, mineral technology, and economic development studies are designed to assist the industry, for example, in the exploration and development of gold and industrial mineral deposits.

## NEW BRUNSWICK

In 1984, New Brunswick's mineral production increased by 16.7 per cent to $590 million, of which $347 million was for zinc, $54 million for lead and $48 million for silver.

The New Brunswick mineral industry is growing rapidly due to the discovery in the early 1970s of rich potash deposits in the Sussex region. The first mine began production in 1983, a second will follow in 1985 and a third may be completed by 1990. Other growth factors include: the expansion of the Brunswick Mining and Smelting Corporation Limited zinc-lead mining and smelting facility near Bathurst; the start of production of the Brunswick Tin Mines Limited tungsten-molybdenum mine south of Fredericton; and the rehabilitation and reopening of the antimony mine at Lake George by early-1986. The New Brunswick government estimates that the total value of mineral production could exceed $1 billion by the end of 1990, accompanied by expanding job opportunities.

Another factor that could accelerate development in the mining sector is the establishment of a pilot plant to test the sulphation roast-leach method for processing the complex base-metal ores found in the Bathurst region. This ore is fine grained and complex, resulting in relatively low recoveries of metals in the concentration stage. The project is jointly financed and managed with the province. Besides increasing recovery of metals from existing operations, this process could allow development of deposits currently considered uneconomical.

The Canada - New Brunswick Mineral Development Agreement was signed in June 1984, with spending commitments of $22.3 million by the provincial and federal governments. Its three main aspects are: geoscientific research; research and development of new technologies; and economic development studies.

## QUEBEC

In 1984, the value of mineral production in Quebec remained virtually unchanged from 1983 at $2.04 billion, of which $442 million was for gold, $362 for iron ore and $301 for asbestos.

The 1980s have on the whole been a depressed period for the mining industry in Quebec. The value of mineral production has fallen sharply and has been accompanied by reductions in employment and investment. This decline is attributable partly to the continuing effects of the world-wide recession and partly to structural changes that are affecting mineral markets, particularly for iron ore and asbestos. Although the industry reached a low point in 1983, a continued relatively weak performance can be expected if the predicted economic slowdown for 1985 or 1986 takes place.

The mining industry in Quebec is diversified, with more than 15 minerals produced. On the other hand, about 60 per cent of production value derives from four minerals; gold, iron ore, asbestos and copper. Since 1980, the value of gold production has increased by 25 per cent, despite a major decline in price. However, the value of production of the other three minerals has fallen dramatically because of declining prices and volumes produced.

Mining is a major element in the economic base of northeastern and north-central Quebec, as well as the Gaspé and the Eastern Townships. Consequently, the general slowdown of the mining industry has had major regional impacts. Certain mining communities have lost part of their population and, in some cases, specifically Schefferville and Gagnon, towns have been virtually shut down.

Faced with the need to maintain some degree of economic activity in the more remote parts of the province, the Quebec government decided to invest heavily in the mining sector. Accordingly, through an assistance program designed to accelerate investment, Quebec has in the last 18 months committed nearly $120 million to assist the mining sector. This is expected to generate, mining investments of $600 million and create 4,500 temporary jobs and 2,000 permanent jobs. Some 18 projects, in the gold and base-metal sectors in particular, will benefit from this program.

An Economic and Regional Development Agreement was signed on December 7, 1984 by the federal and Quebec governments, which will provide the framework to negotiate an MDA. It will enable the two governments to examine ways to collaborate in geoscientific studies, mineral research and development and market studies.

The mining industry will continue to make an important contribution to the economy of Quebec, but it will no longer be characterized by megaprojects such as the development of the Labrador iron ore mines during the 1960s and 1970s. Rather, it will be characterized by the development of smaller, higher-grade mines. These will likely be precious metal mines or base-metal mines containing significant precious metal byproducts. Because of the smaller size, the impact of each mine will be more localized at the community level.

## ONTARIO

In 1984, the value of Ontario's mineral production increased by 22.1 per cent from 1983 to $4.49 billion. Of this amount, $926 million was for nickel, $552 million for copper, $539 million for uranium, $414 million for zinc, $400 million for gold and $235 million for iron ore.

In northern Ontario some 19 communities are dependent upon the mining industry, which employs about 9 per cent of the area's experienced labour force. This work force will be under continued pressure as the industry struggles against weak commodity prices and demand.

The Griffith iron ore mine near Red Lake, owned by Stelco Inc., is scheduled to close in April 1986, affecting about 280 persons. Although various government programs will cushion the immediate effect of job loss and will aid individuals in their search for new employment, it is not likely that all will be able to find new jobs at other mining operations in northern Ontario. The impact on the Red Lake area in general, and the town of Ear Falls in particular, will be considerable.

Despite the generally gloomy outlook for mining, the exploration industry was very active in Ontario during 1983 and 1984. The main target was gold and activity was strong all across the province. No major discoveries were reported in 1984, but exploration and development took place on ground staked in the rushes of 1982 and 1983.

Three mines are nearing completion in the Hemlo area. The Teck Corporation joint venture with International Corona Resources Ltd. and the adjacent Noranda Mining Inc. properties are scheduled to start production in 1985. These two properties contain more than 30 million t of ore grading over 8 g/t. Immediately to the east, the Lac Minerals Ltd. property is to begin production in 1987, and throughput is expected to exceed 10 000 tpd by 1989. The impact of these developments is being felt in the neighbouring communities of Manitouwadge and Marathon. Within a few years, annual gold production from this region should reach 600 000 oz worth more than $250 million at current prices. A good deal of this wealth will be put into the local economy as wages and salaries.

Also near Marathon, Corporation Falconbridge Copper is continuing underground exploration work on its Winston Lake copper-zinc deposit, prior to deciding whether to bring it into production.

The Detour Lake mine, about 140 km northeast of Cochrane, has now operated for about one year. It is the fifth largest gold mine in Canada and the 500 jobs created are an important addition to the economic base of northeastern Ontario. There is no town at the mine site and services are supplied from Cochrane and Timmins.

Also at Timmins, Kidd Creek Mines Ltd. recently opened the Owl Creek gold mine and is doing underground exploration at the nearby Hoyle Pond gold deposit, which it plans to bring into production around 1987, when the Owl Creek ore will be exhausted.

In 1984, three federal-provincial regional agreements, which had provided information and assistance to the mining industry, terminated. Two agreements were specific to eastern Ontario, the upper Ottawa Valley and the Kirkland Lake area, while the more general Northern Ontario Rural Development Agreement (NORDA) affected the whole of the northern part of the province.

The mining industry in Ontario was less plagued by shutdowns and layoff in 1984 than in 1982-83. At Timmins, Pamour Porcupine Mines Limited shut down the lower-grade, higher cost portions of its gold mine salvage operations, laying off nearly 500 workers.

The Ontario mineral industry is expected to experience continued weakness in 1985 especially if the demand for mineral commodities again falls off due to the predicted slowdown of the world economies. World-wide metal mining overcapacity and production will contribute to worsen the effects of the reduced demand.

## MANITOBA

In 1984, the value of Manitoba's mineral production increased by 3.1 per cent from 1983 to $756 million, of which $239 million was for nickel, $165 million for crude petroleum, $109 million for copper and $68 million for zinc.

Base-metal mining provides the economic base for the northern communities of Flin Flon, Lynn Lake, Snow Lake, Leaf Rapids and Thompson. The low metal prices that have persisted since 1982 have caused a number of temporary and permanent mine closures and hundreds of employees have been laid off. The situation is worsened by declining ore reserves and grades. Given the poor outlook for base-metal markets, mining companies are hesitant to make the capital investments ncessary to improve output at existing mines or develop new orebodies. In particular, the existence of the town of Lynn Lake is threatened by the planned closure by 1985 of the Fox mine because of exhaustion of ore.

In June 1983, the governments of Canada and Manitoba announced a two-year $1 million agreement to conduct geoscientific studies to stimulate mineral exploration in the Lynn

Lake area. In November 1983, the two governments announced a $24.7 million five-year Mineral Development Agreement to: expand the scope of the geoscientific programs to other areas in the north; conduct research to improve health, safety and productivity at existing mines; and investigate new uses for mineral commodities that are not being fully exploited.

The only new mine that opened recently in northern Manitoba was the 1 600 tpd Trout Lake copper-zinc mine near Flin Flon. Concentrate from this mine will ease the shortage of feed to the Hudson Bay Mining and Smelting Co., Limited smelter at Flin Flon.

Sherritt Gordon Mines Limited is continuing an exploration program on the Agassiz gold deposit near Lynn Lake, supported by grants from the federal and provincial governments under the New Employment Expansion and Development (NEED) program. If the orebody proves to be economic, it is planned to coordinate development with closure of the Fox mine.

In May 1984, the Manitoba government approved a $10 million loan as part of the $30 million required to develop access to deeper ore at the Ruttan copper-zinc mine at Leaf Rapids.

The future is brighter at the Thompson nickel mining and smelting complex because of efforts to lower operating costs. This is being achieved mainly by conversion to underground bulk mining methods and the development of an open-pit mine, which will begin production in 1986. While employment levels will not be significantly affected, job security will be improved and the long-term viability of the Thompson operations will be enhanced.

Northeast of Winnipeg, near Bissett, results from an exploration program at the San Antonio gold mine, which was shut down in May 1983, are encouraging. Further work is required and gold prices must improve before the mine is reopened. In the same area, the Bernic Lake tantalum operation, shutdown since 1982, was re-activated as a pilot project to produce ceramic-grade spodumene. About 20 of the former 100 employees were rehired.

Minor amendments were made to the Mining Tax Act in Part IX of Bill 75, passed on August 18, 1983. These amendments were largely to provide greater clarification for the application of the act.

Changes to the Mining Act have been under consideration since 1980, when a commission made recommendations to improve safety conditions in Manitoba mines, many of which have already been implemented. Extensive consultation with labour and the mining industry was held to develop the proposed legislation.

The provincial government is actively pursuing the development of a potash mine and the construction of a 200 000 tpy aluminum smelter. The aluminum smelter project received a major setback in November 1984 when the potential investor, Aluminum Company of America, withdrew from a joint feasibility study. The province and Canamax Resources Inc. are proceeding with a feasibility study for the development of a potash mine near Russell. The partners are attempting to interest foreign governments to provide equity investment and a market for the potash that would be produced.

## SASKATCHEWAN

In 1984, the value of Saskatchewan's mineral production increased by 33.2 per cent from 1983 to $3.78 billion. Of this amount, $2.32 billion was for crude petroleum, $378 million for uranium and $115 million for coal.

Potash sales, down since 1981, have recovered moderately. Uranium production fell sharply in 1983 due to the closure of the Eldorado Nuclear Limited operations at Uranium City, causing the loss of 830 jobs and the virtual shutdown of the community. However in 1984, uranium production expanded as the new Key Lake mine became fully operational. In the south, mining of lignite coal, mainly used by nearby thermal electric generating stations to feed the provincial power grid, has been relatively unaffected by the recession.

Expansions are under way at the Rabbit Lake uranium mining and concentrating facilities and the Belle Plaine solution mining potash operations. No further major uranium, potash or lignite coal projects are likely to commence until the late 1980s. However, encouraging results from gold exploration in the north may lead to mine developments if the outlook for future gold prices is favourable.

In May 1984, the federal and provincial governments signed a $6.38 million Mineral Development Agreement supporting geoscientific programs in the north. It will also facilitate research to improve productivity and investigate new uses for industrial mineral commodities. It is hoped that this information will lead to a number of new development opportunities.

In March 1984, the Saskatchewan government announced a number of changes to the Mineral Disposition Regulations 1961 designed to stimulate mineral exploration and development.

In the latter half of the 1980s the potash mining industry in Saskatchewan will have to compete for markets with other producers coming on-stream in New Brunswick and overseas. Uranium producers may face softening prices as deposits in Australia are brought into production. Lignite coal production for consumption in mine-mouth power stations will expand. In terms of employment and value of production, the mineral industry will likely maintain its contribution to the provincial economy, however, there is no reason to expect strong expansion.

## ALBERTA

In 1984, the value of mineral production in Alberta was $25.96 billion. Of this amount, $14.93 billion was for crude petroleum, $6.98 billion for natural gas, $2.71 billion for natural gas byproducts, $557 million for sulphur and $480 million for coal.

Coal production, the principal mining activity in Alberta, is eclipsed in economic importance by the petroleum industry. However, it is important to the economy of a number of communities. The communities of Grande Cache, Edson and Hinton have been affected by layoffs at nearby mines as a result of reduced exports of thermal and coking coal, primarily to Japan. This has been partially offset by the start-up of the new Gregg River coking coal mine in April of 1983 and the Obed Mountain thermal coal mine in 1984.

Mines supplying coal for domestic electric power generation continue to produce at normal rates. In September of 1983, the Highvale mine opened at Keephills west of Edmonton. New mines are under construction at Genesee, also west of Edmonton, and at Sheerness, east of Drumheller.

Near Coleman in southeast Alberta, rising costs forced the closure of thermal coal reclaiming operations. Several proposed coal projects have been deferred until offshore markets improve.

Sulphur produced as a byproduct of sour natural gas is Alberta's other major nonfuel mineral commodity. Demand recovered during 1983-84 and prices were good. Inventories are falling as a result of increasing demand and falling production from depleting reservoir reserves.

## BRITISH COLUMBIA

In 1984, the value of British Columbia's mineral production was $3.35 billion, up 15.5 per cent from 1983. Of this amount, $1.03 billion was for coal, $548 million for copper, $436 million for crude petroleum, $389 million for natural gas and $130 million for zinc. The increase in total value of production was mainly due to the start-up of shipments from the northeast coalfields.

Contractor employment in the mining industry was at an unprecedented high of 3,500 in 1983, mainly because of the construction of the northeast coal mines. Within the industry itself, employment dropped from the 1981 peak of 20,240 to 16,600 in 1983. The Mining Association of British Columbia reported that 4,060 employees, or nearly a quarter of the industry's workforce, were laid off at various times during 1983. Some of the mine closures that began in 1983 were extended into 1984 and persistent low prices for base-metals caused more mines to shut down.

During 1983, Aluminum Company of Canada, Limited (Alcan) applied to the British Columbia government for permission to proceed with the Kemano completion project, which would double Alcan's hydro generating capacity in the province and thereby permit the construction of two new aluminum smelters. By late-1984, falling aluminum prices caused Alcan to withdraw the application pending recovery of the aluminum market.

The outlook for British Columbia's large low-grade copper-molybdenum mines is not promising. Although many are being maintained on a stand-by basis, significant improvements in copper and molybdenum markets would be required to make them viable. More closures and shakeouts can be expected.

The British Columbia mining industry should see the development of a number of small-tonnage, high-grade, underground precious metals mines over the next few years. Although these mines will not have the economic impact of the large copper-molybdenum mines, they will be more labour intensive. If this type of development occurs, the availability of experienced underground miners could become a problem.

On November 23, 1984 the federal and provincial governments signed a ten-year Economic and Regional Development Agreement for coordinated initiatives. Three sectors including mineral development were identified as areas in which specific programs, should be developed.

## NORTHERN CANADA

During 1983 and 1984, the Department of Indian Affairs and Northern Development (DIAND) continued to work on the development of a northern mineral policy. As part of a consultative process, eight issue papers will be released and by the end of 1984 three of these papers were available.

A new northern roads policy was approved by the federal Cabinet in 1983. Over the next five years, this policy is expected to provide an estimated $100 million for northern road construction. The level of assistance planned for northern resource roads to 1988 has been doubled.

In 1983, agreement was reached among the federal government, territorial governments and native groups on a new land use planning process for northern Canada. Organization for the implementation of land use planning proceeded through 1984.

## NORTHWEST TERRITORIES

Ten mines operated in 1983 and 1984 producing gold, silver, lead, zinc, cadmium, copper and tungsten. Although depressed metal prices and labour strife resulted in intermittent closures and cutbacks at several mines, production capacity continued to increase. In general, the mines in the Northwest Territories demonstrated an ability to weather the economic downturn.

In 1984, the value of mineral production increased by 24.0 per cent from 1983 to $738 million, which included $345 million for zinc, $190 million for gold, and $65 million for lead.

The Cantung tungsten mine of Canada Tungsten Mining Corporation Limited, which was closed throughout most of 1983, reopened in December. About 120 of the 200 workers laid off were recalled. About 50 workers remained on-site during the closure.

Cominco Ltd.'s Pine Point mine was closed in January 1983. However, the mine was reopened the following June after renegotiation of contracts with: Canadian National Railways covering freight cost; the United Steel Workers covering wages, benefits and working conditions; Northern Canada Power Corporation covering power costs; and the Trail smelter covering smelter charges. Substantial improvements in costs of production were achieved. Also, a preproduction stripping program was initiated at the mine, partially funded by the federal government under the NEED program.

By 1984, employment in Northwest Territories mines returned to the 1982 levels of around 2,400 persons. Start-up of the Salmita gold mine of Giant Yellowknife Mines Limited in December 1983 created 90 new jobs.

The near-term future of mining in the Northwest Territories looks stable. There are a number of small gold and silver properties that could be brought into production with less than two years lead time. Many of these would be developed on a fly-in fly-out basis and would not require extension of infrastructure or community services.

## YUKON

Mining, formerly the lead industrial activity in Yukon, is now second to tourism in terms of economic contribution. Mineral production in 1984 was valued at $60 million, a decrease of 5.4 per cent from 1983, consisting almost entirely of gold at $40 million and silver at $15 million. Because the possibilities for economic development in Yukon are mainly in natural resources, the Yukon government has established a Mining and Energy Branch.

Despite low silver prices, United Keno Hill Mines Limited kept its Elsa silver mine in production, which provided employment for about 150 workers. The company raised $13 million from an issue of flow-through shares and has reported promising results from an exploration program in the vicinity of the mine.

At the Faro mine of Cyprus Anvil Mining Corporation, which suspended production in 1982, 200 workers participated in a waste stripping program jointly financed by Dome Petroleum Ltd. and the federal government. The future of this mine remains uncertain because of low zinc, lead and silver prices. Other unresolved issues include power rates, a labour contract, and the method to transport concentrates to tidewater. The White Pass and Yukon Railway remains closed because of the loss of concentrate shipments from the Faro mine, which provided the base load.

Although several small underground gold, silver and tungsten deposits in Yukon are being evaluated, the future of the territory's mining industry in the short-term depends on the Faro mine. The output of this mine, with its large requirement for transportation, labour and power when it is operating at full capacity, comprises about 40 per cent of the Yukon economy.

The medium-term outlook of placer mining depends on the price of gold, which is currently near the economic threshold for most operators. Uncertainties involving environmental regulations for placer mining were deferred when water use permits were granted for the 1984 and 1985 seasons. Research is being carried out on various impacts of placer mining on the environment and the issue will be reviewed in 1986.

Exploration expenditures in the Yukon in 1984 were unexpectedly strong. Expenditures in 1983 were about $13 million and expenditures for 1984 may be as high as $25 million. The only property currently in the development stage is the MacTung tungsten deposit. AMAX Inc. may have this property in production in 1986.

**CANADA, PROVINCES AND TERRITORIES, LEADING MINERALS, 1984P**

| | Value of production ($ million) | Proportion of total (per cent) | Change from 1983 (per cent) |
|---|---|---|---|
| **Newfoundland** | | | |
| Iron ore | 867.6 | 87.3 | 21.9 |
| Zinc | 56.2 | 5.7 | 38.2 |
| Asbestos | 23.5 | 2.4 | 40.8 |
| Total | 993.5 | 100.0 | 23.1 |
| **Prince Edward Island** | | | |
| Sand and gravel | 0.9 | 100.0 | 22.6 |
| Total | 0.9 | 100.0 | 22.6 |
| **Nova Scotia** | | | |
| Coal | 162.6 | 55.5 | 11.6 |
| Gypsum | 43.7 | 14.9 | 17.8 |
| Sand and gravel | 21.6 | 7.4 | -6.4 |
| Cement | 17.1 | 5.8 | 70.6 |
| Total | 293.0 | 100.0 | 12.6 |
| **New Brunswick** | | | |
| Zinc | 346.7 | 58.7 | 34.0 |
| Lead | 53.9 | 9.1 | 29.8 |
| Silver | 47.7 | 8.1 | -47.0 |
| Coal | 30.3 | 5.1 | 2.1 |
| Total | 590.4 | 100.0 | 16.7 |
| **Quebec** | | | |
| Gold | 442.2 | 21.6 | -3.4 |
| Iron ore | 362.4 | 17.7 | -2.8 |
| Asbestos | 301.1 | 14.7 | -6.3 |
| Cement | 146.6 | 7.2 | 14.9 |
| Total | 2,043.4 | 100.0 | 0.2 |
| **Ontario** | | | |
| Nickel | 925.9 | 20.6 | 68.3 |
| Copper | 552.2 | 12.3 | 20.3 |
| Uranium | 538.7 | 12.0 | -1.4 |
| Zinc | 414.0 | 9.2 | 24.8 |
| Total | 4,493.7 | 100.0 | 22.1 |
| **Manitoba** | | | |
| Nickel | 239.3 | 31.7 | 3.5 |
| Petroleum | 165.0 | 21.8 | 7.9 |
| Copper | 109.3 | 14.5 | -22.1 |
| Zinc | 68.3 | 9.0 | 21.3 |
| Total | 755.7 | 100.0 | 3.1 |
| **Saskatchewan** | | | |
| Petroleum | 2,323.7 | 61.4 | 30.3 |
| Potash | x | x | x |
| Uranium | 377.6 | 10.0 | 211.1 |
| Total | 3,785.2 | 100.0 | 33.2 |
| **Alberta** | | | |
| Crude petroleum | 14,927.0 | 57.5 | 8.8 |
| Natural gas | 6,981.4 | 26.9 | 6.1 |
| Natural gas byproducts | 2,717.0 | 10.5 | 3.8 |
| Sulphur, elemental | 556.9 | 2.1 | 34.4 |
| Total | 25,963.7 | 100.0 | 7.7 |

3.9

|  | Value of production<br>($ million) | Proportion of total<br>(per cent) | Change from 1983<br>(per cent) |
|---|---|---|---|
| **British Columbia** |  |  |  |
| Coal | 1,026.9 | 30.6 | 78.9 |
| Copper | 547.6 | 16.3 | -7.3 |
| Petroleum | 436.0 | 13.0 | 7.9 |
| Natural gas | 389.4 | 11.6 | 2.1 |
| Total | 3,353.7 | 100.0 | 15.5 |
| **Yukon Territory** |  |  |  |
| Gold | 40.4 | 67.8 | -19.8 |
| Silver | 15.3 | 25.7 | 122.7 |
| Sand and gravel | 1.6 | 2.7 | 7.8 |
| Total | 59.6 | 100.0 | -5.4 |
| **Northwest Territories** |  |  |  |
| Zinc | 345.2 | 55.8 | 27.9 |
| Gold | 190.0 | 30.7 | 31.4 |
| Lead | 65.0 | 10.5 | 35.7 |
| Total | 737.8 | 100.0 | 24.0 |
| **Canada** |  |  |  |
| Petroleum | 17,887.8 | 41.5 | 11.2 |
| Natural gas | 7,514.6 | 17.4 | 6.2 |
| Natural gas byproducts | 2,782.9 | 6.4 | 3.8 |
| Coal | 1,814.0 | 4.2 | 39.1 |
| Iron ore | 1,470.9 | 3.4 | 15.8 |
| Zinc | 1,438.0 | 3.3 | 26.7 |
| Copper | 1,351.4 | 3.1 | -1.0 |
| Gold | 1,227.8 | 2.8 | -0.2 |
| Nickel | 1,165.2 | 2.7 | 49.1 |
| Uranium | 916.3 | 2.1 | 37.2 |
| Total | 43,070.7 | 100.0 | 11.8 |

P Preliminary; x Confidential.

# Canadian Reserves of Selected Mineral Commodities

**(Data available in 1984)**

**J. ZWARTENDYK**

Any assessment of future supply of a given mineral commodity from Canadian mines requires information on current working inventories, i.e., on the amounts of ore known to be present in operating mines and on additional known tonnages in deposits that are close to being mineable profitably. The tonnages that - in 1983 and 1984 - were fairly well delineated and judged to be mineable are reported below as "reserves". The limits of what is included in reserves are further specified in each case.

| | 1983 | 1984 |
|---|---|---|
| **(A) Copper** | 17 021 500 t[1] | 16 170 100 t[1] |
| **Nickel** | 7 580 800 t | 7 339 500 t |
| **Lead** | 9 028 800 t | 9 053 800 t |
| **Zinc** | 26 077 300 t | 26 449 500 t |
| **Molybdenum** | 494 300 t | 445 800 t |
| **Silver** | 31 381 t | 30 222 t |
| **Gold** | 837 707 kg | 1 159 773 kg |

The quantities of the metals listed above are contained in ore recoverable from current mines (including those "temporarily" closed) and from deposits that had been committed for production up to January 1, 1983 and 1984 respectively.

These quantities represent proved and probable tonnages; any additional "possible" tonnages are not included.

**(B) Iron** 1 775 million t

This is the quantity of iron contained in known crude ore in producing mines[2]. Ore in undeveloped deposits is not included.

| | 1983 | 1984 |
|---|---|---|
| **(C) Asbestos** | 43.5 million t | 41.4 million t |

This represents the fibre content (on average, a little over 5 per cent) of, respectively, 803 million t (1983) amd 760 million t (1984) of mineable ore reserves in producing mines.

| | |
|---|---|
| **(D) Potash** | 14 000 million t ($K_2O$ equivalent), corresponding to 23 000 million t KCl product (standard fertilizer - exported product) |

This amount would be recoverable by conventional mining (to a depth of about 1 100 m) from known potash deposits. At least an additional 42 000 million t ($K_2O$ equivalent) would be recoverable from known deposits by solution mining at depths beyond 1 100 m; this would represent 69 000 million t of KCl product.

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[1] Metric tonne (2 204.62 pounds avoirdupois).

[2] Estimate updated to 1984 from "MR 170, A Summary View of Canadian Reserves and Additional Resources of Iron Ore", Energy, Mines and Resources Canada, 1977.

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## (E) Uranium

| Mineable at uranium prices of: | "Reasonably Assured" Proven (Measured) (t U) | "Reasonably Assured" Probable (Indicated) (t U) |
|---|---|---|
| 1983[3] | | |
| $Cdn 115/kg U or less: | 35 000 | 150 000 |
| $115 to $170/kg U: | 1 000 | 9 000 |
| 1984[4] | | |
| $Cdn 100/kg U or less: | 30 000 | 162 000 |
| $100 to $150/kg U: | | 41 000 |

The tonnages refer to uranium contained in mineable ore[3]. Unless otherwise specified, uranium "reserves" in Canada refer to the tonnages mineable at uranium prices in the low range only.

## (F) Coal

| | |
|---|---|
| - **Bituminous** | 3 087 million t (of which 2 030 million t could be used for metallurgical purposes) |
| - **Sub-bituminous** | 918 million t |
| - **Lignitic** | 2 263 million t |

These represent tonnages that could be profitably recovered as raw coal, given current technology and economics, from measured (proven) and indicated (probable) coal in deposits that are legally open to mining. For the purpose of making these estimates, it was assumed that coal sales would cover the costs of any required infrastructure not already in place[5].

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[3] EP 83-3, "Uranium in Canada: 1982 Assessment of Supply and Requirements", Sept. 1983, Energy, Mines and Resources Canada.

[4] Communiqué October 11, 1984, Energy, Mines and Resources Canada.

[5] CANMET Report 83-2 OE, "Coal Mining in Canada: 1983", Energy, Mines and Resources Canada, 1984.

# Canadian Reserves, Development and Exploration

W.H. LAUGHLIN

## RESERVES

Table 1 illustrates the annually changing levels of Canadian reserves of seven major metals, in terms of the metal content of ore. These quantities were computed on the basis of information provided by mining companies. They pertain to ore tonnages that, as far as could be determined, were known at a level of assurance equivalent to "proven" (measured) and/or "probable" (indicated). Tonnages reported as "possible" (inferred) were not included. Table 2 shows a province-by-province breakdown for reserves on January 1, 1984.

While the term "reserves" is widely used to refer to that part of mineral resources that, on a given date, is well delineated and considered economically mineable, the reserves given here are confined to those in producing mines and in deposits that have been committed for production. These reserves constitute the reliable core of information. For other deposits, where concrete steps have not been taken by companies to prepare them for mining, judgments by outsiders regarding economic mineability would not form a consistent basis for reporting reserves. The purpose of the "reserves" restrictions used here is to avoid such subjective judgments.

The quantities of reserves reported cannot, by themselves, give any indication of whether or not Canada might be running out of economically mineable minerals. Future production will draw not only on the 1984 reserves but also on additional reserves yet to be developed -- from discoveries, from extensions to known orebodies and from known but currently marginal or uneconomic material.

Canada has a large number of potential supply sources that are less assured than current reserves. The most promising of these are listed in EMR's biennial mineral bulletin on Canadian reserves[1]. That publication tabulates the specific operations at which current reserves are reported. It lists also those deposits that are considered the likeliest for future development, with ratings on their relative promise. Another bulletin[2] deals with Canadian capability for metal production both from operating mines and from known deposits for which future production can be considered likely.

## GOLD

At the beginning of 1984, Canadian reserves of gold were 38 per cent higher than a year earlier, largely because of new reserves in deposits committed for production during 1983.

For the first time, reserves from all three deposits in Ontario's Hemlo gold camp were counted in the national total. Reserves in other deposits newly committed for production elsewhere were also added for the first time at the beginning of 1984, notably Falconbridge's Lac Shortt (Quebec), Inco-Queenston's McBean (Ontario), Noranda's Remnor (Quebec), Flin Flon Mines' Rio (Saskatchewan), Giant Yellowknife's Salmita (N.W.T.), Société Minière Louvem's Chimo (Quebec), Westfield Minerals' Scadding (Ontario), Sigma's Sigma II (Quebec), and Lac Minerals' Lake Shore (Ontario). The McBean mine represents diversification by the giant nickel producer, Inco, into purely precious metal operations. Even though these additions were significant, at least by past standards, each was dwarfed in comparison with the individual contributions made in Ontario's Hemlo area by Noranda-Goliath-Golden Sceptre's Golden

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[1] W.H. Laughlin, Canadian Reserves of Seven Metals as of Jan. 1, 1983, MR 201, Energy, Mines and Resources, Ottawa.

[2] Mineral Policy Sector, Canadian Mines: Perspective From 1983, MR 200, Energy, Mines and Resources, Ottawa. (1984 version in preparation).

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Giant, Teck-Corona's Corona, and Lac Minerals' Williams deposits.

Noteworthy additions to reserves of gold were also made at a number of mines where major expansion projects were under way, such as at Aiguebelle Resources' Dest-Or, Lac Minerals' Macassa, Dickenson-Sullivan's Arthur White, and Lac Minerals-SOQUEM's Doyon mines.

The large net increase in reserves at the beginning of 1984 masked sizeable reductions due to reassessments and write-offs of gold-bearing material at a number of mines and a lack of replenishment of reserves for metal produced during the previous year at several major byproduct gold operations.

### ZINC

Even though, during 1983, markets for zinc fared relatively better than did those for most other metals reviewed here, reserves of zinc were barely up at the beginning of 1984 compared with a year earlier. The outstanding addition to national reserves of zinc was contributed by Cominco's Polaris mine where a large tonnage of new ore was added to the mine's inventory. Rio Algom's new development at East Kemptville (Nova Scotia) added large zinc reserves to the national total. Much new ore was also developed at Mineral Resources International's Nanisivik mine and at Teck-Amax's Newfoundland Zinc mine.

Deletion of all of the underground ore reserves at Cominco's Pine Point operations caused the single largest reduction in zinc reserves. In many mines, new ore development did not keep pace with the zinc ore produced during 1983.

### LEAD

Reserves of lead in early 1984 were not much changed compared with the previous year. Because lead is commonly associated with zinc, Cominco's Polaris mine, the largest contributor to the maintenance of Canadian zinc reserves, was also the largest contributor of new lead reserves. That contribution was partly offset by Cominco's decision to cease counting as "reserves" all of the substantial underground inventory of lead ore at its Pine Point operations. Lead reserves were diminished also because several major producers had not developed as much new ore in 1983 as they had mined.

### NICKEL

Reserves of nickel in early 1984 were somewhat lower than the previous year. The overall decrease at Canada's more than two dozen nickel mines owned by Inco and Falconbridge took place because the ore that was mined throughout 1983 was not matched by newly-developed reserves. Some of the cash flow that in better times might have been used to develop additional ore was directed at lowering the cost of extraction of existing reserves through the implementation of bulk mining and other innovative methods of production.

### SILVER

The 1984 reserves of silver were down slightly from those of the previous year. During 1983, mining outpaced the replenishment of reserves at a dozen major silver producers across Canada. Permanent closures during 1983 and downward reassessment of reserves at a number of operations where silver is an important byproduct also diminished the Canadian total.

### COPPER

Canadian copper reserves in early 1984 were about 5 per cent lower than they had been a year earlier, a reflection of the poor markets facing copper producers.

The biggest reduction in reserves resulted from large-scale reevaluation of copper-bearing material in the reserves inventories of major copper producers in British Columbia, notably at Placer Development's Gibraltar mine and at Noranda's Bell mine, as well as from some permanent mine closures. Reserves were further depressed because ore mined during 1983 at several large-scale operations had not been replenished by the beginning of 1984. The ore development activities were apparently severely restricted.

The largest contribution of new copper reserves came from Noranda's Murdochville (townsite) property, included in Canadian totals for the first time at the beginning of 1984.

### MOLYBDENUM

The weak market for molybdenum over the past few years brought in its wake a decline in molybdenum reserves of more than 9 per cent from 1983 to 1984. This drop took place even though reserves reported at

Amax's Kitsault, Placer Development's Endako and Noranda's Needle Mountain, Copper Mountain and Boss Mountain mines remained unchanged during 1983 while little or no production took place at any of these mines. Reserves that had previously been allocated to some operations as a byproduct were deleted from the national total in 1984 because the molybdenum concentrates that had been expected were not produced.

Reserves were further reduced by write-offs of low-grade material at some mines in British Columbia, notably at Noranda's Brenda mine. Inadequate reserves replenishment for material mined during the course of 1983 at large-scale operations contributed also to lowering the reserves level.

## OUTLOOK

Production at several major mines has been suspended indefinitely, in some cases since 1982. Weak markets for most of the major metals make the early resumption of production at these mines unlikely. For this reason, Table 1 shows estimates of 1985 reserves that exclude the "temporarily" closed mines. More mines can be expected to close if weak prices continue.

Reserves will likely continue to decline, except for gold and silver, as long as the basic market outlook does not change significantly. Should markets improve, some of the mineral material recently judged subeconomic might again be considered reserves, although some of it may have become irretrievable by that time because of revised mining procedures.

## DEVELOPMENT

Energy projects dominate development statistics: of the total commitments in dollars to Canadian mineral development projects in 1984, oil and gas accounted for about one-half, coal for about one-quarter and metals (excluding uranium) for some 15 per cent. Although metal mine/mill development projects appear modest in this context, they affect more regions than do oil, gas, and coal projects. The metallic mineral industry's share of development projects is proportional to its share of the total value of Canadian mineral production (18 per cent).

Figure 1(a) illustrates annual development expenditures since 1968. These have been consistently higher than the more widely publicized expenditures on exploration; the ratio of exploration to development expenditures fluctuates in the 0.5 to 0.8 range, Figure 1(b).

During 1983 a total of $612 million was spent on mine development. Major preproduction development projects included in this total are:

| | |
|---|---|
| Noranda's Golden Giant (Ont.) | gold |
| Teck's Corona (Ont.) | gold |
| Rio Algom's East Kemptville (N.S.) | tin |
| Campbell Red Lake's Detour Underground (Ont.) | gold |
| Westmin's H-W (B.C.) | copper, zinc |
| Agnico-Eagle's Dumagami (Que.) | gold, copper |
| Campbell Resources' S-3 Project (Que.) | copper |

New commitments made in 1984 to develop additional mine/mill metal production capability in Canada amounted to $900 million, about half for new gold production and half for new or expanded base-metal production. Fifty-three per cent of the total was for plants in Quebec and 38 per cent for plants in Ontario. Table 3 shows the individual projects.

In addition to these firm commitments to develop mines and build concentrators, many development projects were under consideration with tentative plans for production. At the beginning of 1984 there were at least 30 such tentative projects with announced estimates of capital costs adding up to some $1 billion. During 1984, many plans were changed and many new ones developed; by the end of the year, there were some 40 tentative projects with capital costs of about $500 million.

The continuing commitments to new mine development in Canada through three years of low metal prices, many mine closures, and excess mineral production capacity are evidence of considerable dynamism and faith in being able to surmount serious obstacles.

## EXPLORATION

Some 1,200 companies are active in exploration for metallic minerals in Canada. Fewer than 15 per cent of these are mining companies with producing mines and these companies' affiliates, but these account for well over one-half of all expenditures on such exploration in Canada.

In 1983, the continuing aura of the gold boom and expectations for higher base-metal prices encouraged predictions that the decline in exploration activity that had started in 1982 would be short-lived and that an upward trend would resume. But this did not occur, largely because metal prices in general did not rise. The price of gold dropped over 20 per cent and that of silver 35 per cent. In base-metals, only zinc was relatively sound. Nickel and molybdenum remained at the mercy of a slumping steel industry. Exploration expenditures declined further, but the expectations of economic improvement kept this decline from being more severe.

Figure 2 illustrates exploration activity in Canada expressed in terms of three yardsticks: total expenditures, new claims recorded and surface diamond drilling. From 1982 to 1983, overall exploration expenditures declined 19 per cent; claim staking rose 68 per cent; and diamond drilling rose slightly. Changes differed considerably among the provinces:

**Exploration Expenditures.** Only the sustained activity in Quebec, Ontario and British Columbia (the gold provinces) saved the decline in exploration expenditures from being a serious retrenchment. These three provinces, accounting for 66 per cent of total exploration expenditures in Canada in 1983, made only modest gains over 1982 expenditures, but that compensated to some extent for the large declines in the prairie provinces and the territories. Preliminary information suggests no significant change in the 1984 level compared with 1983.

**Claim Staking.** This rose everywhere in 1983 except in Saskatchewan. The major gains were in British Columbia (a rise of 153 per cent) and Ontario (11: per cent).

For 1984, preliminary data show that staking declined on a national basis, although Newfoundland and Manitoba gained 145 and 16 per cent, respectively.

**Diamond Drilling.** While the overall gain in metres drilled in Canada from 1982 to 1983 was 7 per cent, this was due almost entirely to the 84 per cent gain in Ontario. Surprising were the declines in Quebec (22 per cent) and British Columbia (10 per cent), which have shared in the intensity of exploration for gold.

Preliminary data for 1984 indicate an increase of as much as 35 per cent in metres drilled for Canada, with major gains in Newfoundland, Quebec and British Columbia. These provinces saw important gold developments during the year.

In summary, exploration activities in 1983 and 1984 were sustained by interest in gold; favoured areas were those that generated most of the exploration news on gold, which were particularily in Ontario. The effect of the 1981 gold discovery at Hemlo in Ontario was profound. Exploration expenditures in Ontario in the three years following that discovery (1982-84) were 165 per cent higher than they had been in the three years preceding it (1978-80); the area of claims staked was 120 per cent larger; and diamond drilling was up 335 per cent. Hemlo brought a new dimension to geological concepts of the formation of gold deposits. Each subsequent gold discovery has been compared with the Hemlo setting.

A federal-provincial survey for 1983 showed that Canadian exploration expenditures were distributed roughly as follows:

| | |
|---|---|
| Precious metals | 45 per cent |
| Copper, Zinc, Lead | 32 per cent |
| Other metals | 16 per cent |
| Nonmetallic minerals | 7 per cent |

During 1984, the persistent weakness in the prices of gold and silver (a further drop of 15 per cent for each during the year) began to show its effect before year's end in curtailed and cancelled projects. The outlook for exploration in 1985 depends heavily on the behaviour of the price of gold. A price around $US 300 per ounce is not high enough to be a strong stimulant to exploration, even with low-cost bonanzas such as Hemlo to spur expectations.

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[1] Oil and gas are not covered by these mineral exploration statistics. In the case of new claims recorded, coal is excluded as well.

## TABLE 1. METAL RESERVES IN CANADA

Quantities of Metals Contained in Proven and Probable Mineable Ore[1] in Operating Mines and Deposits Committed for Production on January 1:

| Metal | Units[2] | 1982[3] | 1983[3] | 1984[3] | 1985 (est)[4] |
|---|---|---|---|---|---|
| Copper | 000 t | 15 815 | 17 022 | 16 170 | 14 940 |
| Nickel | 000 t | 8 013 | 7 581 | 7 339 | 7 305 |
| Lead | 000 t | 10 244 | 9 029 | 9 054 | 7 730 |
| Zinc | 000 t | 29 505 | 26 077 | 26 450 | 25 005 |
| Molybdenum | 000 t | 518 | 494 | 446 | 95 |
| Silver | t | 32 154 | 31 381 | 30 222 | 30 375 |
| Gold[5] | kg | 842 215 | 837 707 | 1 159 773 | 1 194 080 |

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[1] No allowance made for losses in milling, smelting and refining. [2] One t (tonne) = 1.1023113 short tons; one kg = 32.150747 troy ounces. [3] Includes reserves in mines suspended "temporarily". [4] Excludes mines suspended "temporarily" with no return to production scheduled as of January 1, 1985. [5] Excludes placer deposits.

## TABLE 2. METAL RESERVES BY PROVINCE

Quantities of Metals Contained in Proven and Probable Mineable Ore[1] in Operating Mines and Deposits Committed for Production[2] on January 1, 1984

| Metal | Units[3] | Nfld. | N.B. | N.S. | Que. | Ont. | Man. | Sask. | B.C. | Y.T. | N.W.T. | Canada |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Copper | 000 t | 5.7 | 612.5 | 53.8 | 1075.1 | 6924.7 | 855.1 | 28 | 6617.3 | 0 | 0 | 16170 |
| Nickel | 000 t | 0 | 0 | 0 | 0 | 5437.5 | 1901.5 | 0 | 0 | 0 | 0 | 7339 |
| Lead | 000 t | 16 | 4105 | 0 | 2.6 | 192.1 | 20.5 | 1.3 | 1929.7 | 1426.2 | 1360.5 | 9054 |
| Zinc | 000 t | 194.1 | 10226.5 | 90.2 | 422 | 4526.4 | 819.1 | 14.6 | 3563.5 | 2156.9 | 4436.4 | 26450 |
| Molybdenum | 000 t | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 428.8 | 0 | 0 | 446 |
| Silver | t | 26.4 | 11336.7 | 0 | 863.5 | 8713 | 862.9 | 19 | 6111.7 | 2051 | 237.9 | 30222 |
| Gold[4] | kg | 211.8 | 15146.8 | 0 | 226177.8 | 652342.7 | 38352.7 | 3887 | 136443.3 | 4892.4 | 82318.6 | 1159773 |

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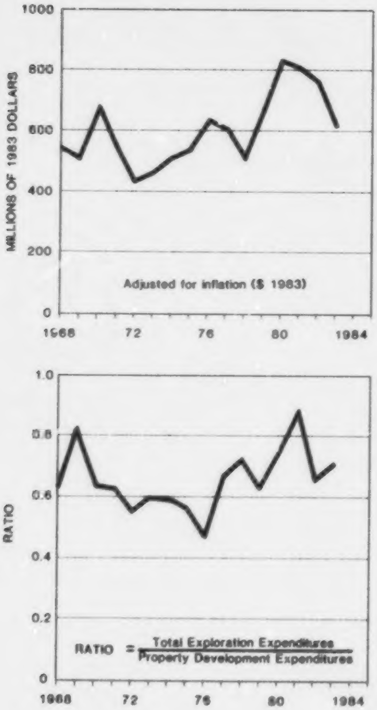
[1] No allowance is made for losses in milling, smelting and refining. [2] Includes reserves in mines suspended "temporarily". [3] 1 t (tonne) = 1.1023113 short tons. [4] Excludes placer deposits.

**TABLE 3. MAJOR DEVELOPMENT PROJECTS ANNOUNCED DURING 1984**

| Operating Company | Project | Metal | Start-up year | Capital cost |
|---|---|---|---|---|
| | | | | ($ million) |
| Lac Minerals Ltd. | New Mine and mill at Hemlo, Ontario. | Gold | 1986-90 | 250.0 |
| | Underground development at La Mine Doyon, Quebec. Surface installations. | Gold | 1985 | 30.0 |
| Les Mines Selbaie | New open pit mine (A-1 orebody), Quebec. | Zinc<br>Copper | 1986 | 128.0* |
| Corporation Falconbridge Copper | 5300 feet shaft and u/g development (Ansil deposit), Quebec. | Copper | 1991 | 125.0* |
| | New mine development (Winston Lake, Ontario). | Zinc | 1986 | 42.0 |
| Noranda Inc. | Development of Murdochville townsite deposit, Quebec. | Copper | 1988 | 84.0* |
| | Golden Giant mine, Ontario - increase over previous estimate | Gold | 1986 | 42.0 |
| Sullivan Mines Inc. | Reopening of Eldrich mine, Quebec. | Gold | 1986 | 27.6* |
| Campbell Resources Inc. | Expansion of plant facilities for exploration and development, Quebec | Copper<br>Gold | on-going | 25.3* |
| Starrex Mining Corp. | New mine at Star Lake, Saskatchewan | Gold | ? | 25.0 |
| Rio Algom Limited | Increased estimate - East Kempville mine and mill, Nova Scotia. | Tin<br>Copper<br>Zinc | 1985 | 20.0 |
| Placer Development Limited | Mill improvements for recovery of precious metals at Equity Silver mine, British Columbia | Silver<br>Copper | 1985 | 12.5 |
| Abcourt Silver Mines Inc. | New mine and mill incorporating former producer (Barvue mine, Quebec). | Silver<br>Zinc | ? | 12.0* |
| Aiguebelle Resources Inc. | Increase mine and mill capacity 600 to 1000 tpd, Quebec. | Gold | 1985 | 12.0* |
| Others | Twelve additional projects, each costing less than $12 million, including four new or re-opened mines | Gold<br>Copper<br>Zinc<br>Antimony | - | 63.6* |
| | | | TOTAL | 899.0 |

* Includes Quebec government grants which, for these projects, total $76.3 million.

FIGURE 1

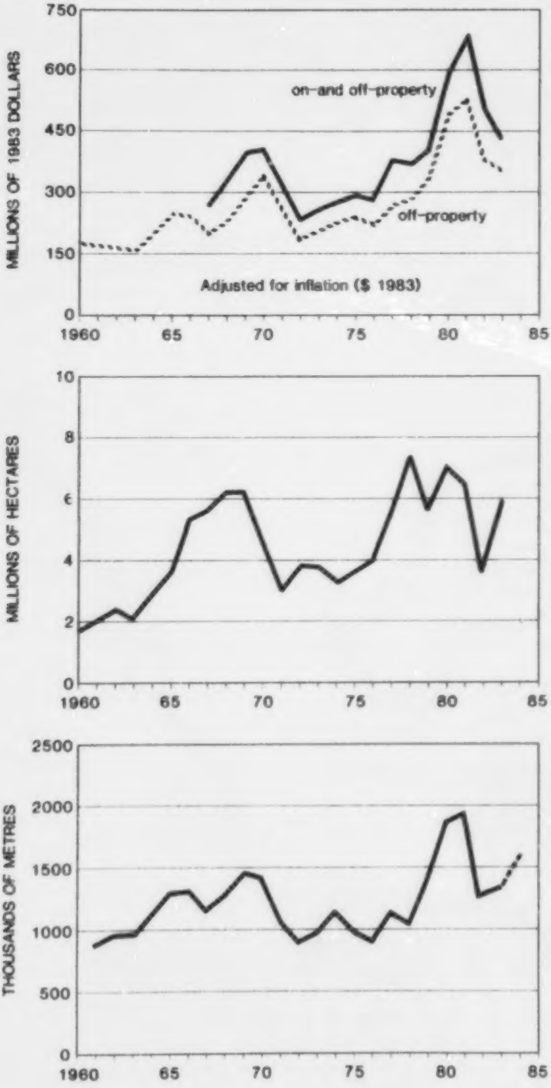


**(a)**
**EXPENDITURES**
**ON PROPERTY**
**DEVELOPMENT**

**(b)**
**EXPLORATION**
**VS**
**DEVELOPMENT**

## FIGURE 2

## MEASURES OF EXPLORATION ACTIVITY



**(a)**

**EXPENDITURES ON MINERAL EXPLORATION**

**(all minerals except oil and gas)**

**(b)**

**AREA OF MINING CLAIMS AND CLAIM BLOCKS RECORDED**

**(c)**

**SURFACE DIAMOND DRILLING**

**(all minerals except oil and gas)**

# Aluminum

G. BOKOVAY

After a strong recovery in 1983 from the effects of the 1981-82 recession, aluminum demand began to ease somewhat during the second quarter of 1984. Unfortunately, aluminum producers continued to bring idled capacity back into production. This created a substantial build-up in aluminum inventories which began to exert considerable downward pressure on prices. Moreover, the fall of prices was exacerbated by consumer destocking in anticipation of even lower prices. In particular, the absence of Japanese buyers for long periods had a distressing effect on metal prices.

In an attempt to bolster prices, non-socialist aluminum producers began to announce production cutbacks toward the end of the second quarter of 1984. While prices did recover slightly in the fourth quarter, they had slipped back to near 1984 lows by the end of the year. Since demand is not expected to pick-up dramatically in the first quarter of 1985, improvement in the aluminum market will require additional production cutbacks.

While the majority of recent cutbacks have been deemed to be temporary in nature, some capacity may well be permanently closed in view of a major geographical restructuring which the industry has been, and is still undergoing. At a time when competition between producers has become more intense, rising energy costs particularly for fossil fuels, has resulted in substantial differences in the cost of the factors of aluminum production between regions. These cost differences have already resulted in a drastic cutback in permanent primary aluminum capacity in Japan, owing to its dependence on imported oil. In addition, widespread permanent cutbacks in primary capacity could also become a reality in the United States and western Europe.

Although Canada, with relatively large quantities of low cost hydro-electric power, will be a major beneficiary of this relocation in smelting capacity, the restructuring of the industry will introduce fundamental changes to those factors influencing long-term aluminum supply.

With changes in several of the key determinants of aluminum consumption, the outlook for aluminum is not as optimistic as in the late 1970s, although it still remains favourable.

## CANADIAN DEVELOPMENTS

Two companies produce primary aluminum in Canada - Canadian Reynolds Metals Company, Limited, a subsidiary of Reynolds Metals Company of the United States and the Aluminum Company of Canada, Limited (Alcan), a subsidiary of Alcan Aluminum Limited of Montreal. Canadian Reynolds operates a 158 760 tpy capacity smelter at Baie Comeau, Quebec, while Alcan has smelters at Jonquière, Grande Baie, Isle Maligne, Shawinigan and Beauharnois in Quebec and at Kitimat in British Columbia, with a combined total capacity of 1 075 000 tpy. The most recent smelter to be constructed in Canada is located at Grande Baie. This smelter, with a capacity of 171 000 tpy, became fully operational at the end of 1983.

At the end of 1984, all Canadian smelters were operating to capacity with the exception of Alcan's Arvida works in Jonquière which was operating at about 86.5 per cent of its installed capacity of 432 000 t. This smelter had been operating at over 95 per cent of capacity until October when production was reduced by a further 37 500 tpy in response to growing metal inventories and severely depressed prices.

Alcan operates the only alumina refinery in Canada which is located at Jonquière. The plant has a capacity of 1.2 million tpy of metallurgical grade alumina and alumina derivatives. Bauxite is imported principally from related companies in Brazil and Guinea. The output of metallurgical alumina

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from the Jonquière plant is consumed at Alcan's smelters in Quebec. Alcan also imports alumina for its eastern Canadian smelters from Jamaica while Alcan's Kitimat smelter is supplied with alumina principally from Australia and Japan. Alumina for the Canadian Reynolds smelter in Baie Comeau is imported from West Germany, Jamaica and the United States.

Canadian production of aluminum in 1984 is estimated at about 1 200 000 t compared to 1 091 000 t in 1983. Canadian exports of primary smelter products for the first nine months of 1984 were down to 628 000 t compared to 699 000 t recorded for the same period of 1983. However, shipments to the United States, Canada's largest export market, increased to 470 000 t from 452 000 t in 1983. The largest decline was registered in the Asian market with exports for the first three quarters of 1984 totalling 135 838 t compared to 226 805 t for the same period in 1983.

In conjunction with the successful renegotiation of its lease for the water rights on the Péribonca River in Quebec, Alcan announced a major $3 billion smelter modernization and expansion program for that province, over the next 30 years. Within this program, the most important single project will be the new Laterrière smelter in the Lac St. Jean region, which the company formally announced in April. The new $1 billion smelter will have a capacity of 248 000 tpy, and will replace about 135 000 tpy of the oldest capacity at the nearby Arvida works in Jonquière. The first of three potlines at the new smelter, each with a capacity of 82 700 tpy is expected to be in production in mid-1988.

Alcan has announced that the new smelter will employ the company's new energy efficient "275" cell technology. Operating at 275,000 amps, the new cell will use about 10 per cent less energy than those cells operating at Alcan's new Grande Baie plant.

In British Columbia, Alcan filed an application at the beginning of 1984 for permission to proceed with its Kemano Completion Project that included additional hydro-electric generating facilities and two new aluminum smelters in British Columbia. However, in late October in response to poor market conditions, Alcan asked the province of British Columbia to postpone further review of the company's application.

During 1984, Canadian Reynolds Metals Co. Ltd. continued work on an expansion of its Baie Comeau smelter begun in 1982, and which was made possible by attractive power rates offered by Quebec Hydro. The $500 million project will increase primary smelting capacity by 113 000 tpy. In addition, existing potlines will be modernized through a conversion to new Sumitomo technology. The modernization will also include the installation of new pollution control equipment, upgraded handling facilities for raw materials and finished goods, increased storage facilities and an additional casting capability. The expansion of smelting capacity at Baie Comeau, which is scheduled for completion in March 1985, is expected to create about 400 more permanent jobs.

In March 1984, state-owned Aluminum Pechiney of France signed an agreement with Quebec and Alumax Inc. of the United States for the construction of a $1.5 billion 230 000 tpy aluminum smelter at Bécancour, Quebec. With an attractive long-term power agreement with Hydro Quebec, including discounts around 50 per cent for the first few years of operation, it has been estimated that the new smelter will break even at aluminum prices around 45 cents (U.S.) per pound.

The new operating company known as l'Aluminerie de Bécancour is controlled 50.1 per cent by Aluminium Pechiney, while Alumax and the Quebec government's Société Generale du Financement (SGF) each have a 24.95 per cent interest. At the end of 1984, construction at the site was well under way, with the first 115 000 tpy potline expected to be in production in mid-1986 and the second at the end of 1987. It is expected that the smelter will employ about 845 persons.

Also in Quebec, Kaiser Aluminum and Chemical Corporation of the United States and the provincial government undertook a prefeasibility study in 1984 for a new aluminum smelter that would be built near Sept-Iles. A decision on whether to proceed is expected in the first quarter of 1985.

In Manitoba, the Aluminum Company of America (Alcoa) and the provincial government undertook a prefeasibility study in 1984 for an aluminum smelter. However, in December, Alcoa formally announced that it was abandoning its plans for the 200 000 tpy smelter in view of what it termed as the adequacy of current and planned world primary aluminum capacity to meet anticipated demand. Manitoba is discussing with other aluminum producers the possibility of constructing a smelter, with a target date of 1990.

## WORLD DEVELOPMENTS

Western world inventories of aluminum rose steadily throughout 1984. The International Primary Aluminum Institute (IPAI) reported that in October, total inventories including aluminum scrap, primary and secondary ingot, metal in process and finished mill products, stood at 4.359 million t compared to 3.67 million t in December 1983. With falling metal prices, aluminum producers in the United States and western Europe instituted or announced production cutbacks totalling 737 000 tpy of capacity during the June to November period. Since new capacity continued to be brought into production elsewhere in the world and that over 300 000 t of announced cutbacks had not been implemented, average daily production in November was 33.9 thousand t. This was only marginally lower than in June when daily average production was 34.7 thousand t.

In the United States, the utilization of smelting capacity rose to about 87 per cent in the second quarter of 1984, and then fell to less than 75 per cent by year-end, with production cutbacks totalling more than 500 000 t. The Aluminum Association Inc. of the United States reported that for the first nine months of 1984, imports of aluminum in all forms were up by 39.8 per cent to 1.18 million t from the same period in 1983, due to the effects of the strong U.S. dollar.

Production cutbacks in the United States began in May with the announcement by Martin Marietta that it was cutting production at The Dalles, Oregon plant. Most major producers including Alcoa, Kaiser, Reynolds, Alumax and Consolidated Aluminium subsequently made similar announcements.

During 1984, the U.S. aluminum industry underwent significant ownership changes. In October, the U.S. Justice Department approved a modified proposal whereby Alcan would acquire a significant portion of the assets of Arco Aluminum. A proposal made by Alcan at the beginning of 1984 had raised anti-trust objections on the grounds that it would lessen competition in the U.S. market. While the accord allows Alcan to acquire Arco's 163 000 tpy smelter at Sebree, Kentucky, Arco's share of the alumina refinery at Aughinish, Ireland, it is restricted to a 40 per cent interest in Arco's new Logan County, Kentucky rolling mill. Arco later stated that it wishes to dispose of its 60 per cent share of the Logan County mill, its remaining smelter at Columbia Falls, Montana and its share of the Alpart alumina refinery in Jamaica.

A second major sale in 1984 involved the takeover of certain of the aluminum assets of Martin Marietta by Comalco Limited of Australia. Comalco will acquire the 168 000 tpy capacity Goldendale, Washington smelter, a rolling mill and recycling facility at Lewisport, Kentucky and an alumina unloading facility at Portland, Oregon. Martin Marietta was reportedly trying to sell its remaining 82 000 tpy smelter at The Dalles, Oregon and its 635 000 tpy alumina refinery in the U.S. Virgin Islands. In late November, the company announced that it was closing The Dalles smelter since no buyer had been found.

In Australia two new alumina refineries began operations in 1984. These were the 500 000 tpy Wagerup plant of Alcoa of Australia in western Australia which had been mothballed since its completion in 1982 and the 1.2 million tpy Worsley refinery of Reynolds Metals, BHP Minerals, Shell Co. of Australia and Kobe Alumina Associates.

Two new smelters also became fully operational in 1984. Comalco Limited commissioned the second potline of its Boyne Island smelter in Queensland. The smelter which has a capacity of 206 000 tpy cost $A 680 million. The second new smelter, at Tomago in New South Wales, is owned by Aluminium Pechiney, Gove Alumina, the A.M.P. Society of Australia, VAW of Australia and Hunter Douglas. This smelter which cost $A 650 million has a capacity of 230 000 tpy.

During 1984, Alcoa of Australia Ltd. announced the restart of construction to its hortland aluminum smelter. Alcoa suspended work on the project in 1982 because of depressed world markets. The $A 1.15 billion smelter will have a capacity of 300 000 tpy. The first potline is expected to be completed in late 1986 and the second in 1988. Other participants in the project include the Victorian government, Hyundai Corp. of South Korea and the Commonwealth Superannuation Fund Investment Trust.

During 1984, it was announced that Reynolds Metals, the western Australia government, the ICC-Kukje Group of Korea and the Griffin Metal Coal Mining Co. would participate in a feasibility study for a new 220 000 tpy aluminum smelter in western Australia. The smelter which would be built south of Perth, at Kemerton, will cost about $A 800 million. Power costs for the smelter will reportedly be A 1.6 cents per kWh initially and then increased to 2.2 cents by 1990.

In September, Alcan announced that it was postponing the start-up of the third potline at its Kurri Kurri smelter in New South Wales. The company said that the delay in bringing the 50 000 tpy potline into production was due to poor market conditions.

In Brazil, it was announced in August that the Alumar expansion project would proceed. The Alumar development is owned by Alcoa Aluminio and Billiton and will have the smelting capacity increased from the recently installed 100 000 tpy to 245 000 tpy, through the construction of a second potline and by technical improvements to existing facilities. The expansion, which should be completed by 1986 will involve some Brazilian investment.

During 1984, work continued on the Albras/Alunorte project owned by CVRD of Brazil and the Japanese consortium, Nippon Amazon. The first of four 80 000 tpy potlines is expected to be in production in October 1985. A 800 000 tpy alumina refinery is also being built.

In Venezuela, Aluminio Del Caroni S.A. (Alcasa) announced a modernization and expansion of its plant at Puerto Ordaz that will increase production by 80 000 tpy. The smelter currently has a capacity of 120 000 tpy. Venezuela's other producer, Venalum, which is owned by the state and Japanese companies, was also reported to be considering an expansion of its smelter from 280 000 tpy to 350 000 tpy. However, with the apparent difficulties that had arisen between Venalum and Japanese buyers on a new price agreement for aluminum exported to Japan, this expansion could be delayed.

Venezuela is proceeding with the development of a bauxite mine in Los Pijiguaos. The $US 450 million project is expected in production by mid-1986 and will have the potential to produce up to 4.5 million tpy. Reserves in the area have been estimated at between 4 and 5 billion t. Venezuela currently imports all of its bauxite requirements from Brazil, Guyana, Sierra Leone and Surinam.

In 1984, Reynolds Metals announced that it was phasing out its bauxite mining operations in Jamaica operated by Reynolds Jamaica Mines. However, the Jamaican government and aluminum producers reached an agreement during the year for a new tax regime applicable to the mining and export of bauxite. The agreement includes a production levy indexed to 6 per cent of the average realized price for primary aluminum and a royalty payment of 50 cents (U.S.) per dry tonne of bauxite. The agreement also provides incentives for increased production.

Also during 1984, Jamaica and Colombia announced that they would cooperate to build an aluminum smelter in Colombia using Colombian coal for power and Jamaican alumina, if the feasibility study is favourable. The smelter with a capacity of 140 000 tpy could come on-stream by 1990.

In India, the state-owned National Aluminum Company Ltd. (NALCO) is proceeding with a bauxite/alumina/aluminum development in the State of Orissa. The project includes an 800 000 tpy alumina refinery at Damanjodi and a 218 000 tpy smelter at Angul. The project, which is scheduled for completion in 1986 or 1987, should allow India to become self-sufficient in aluminum.

In Ghana, the government and the Volta Aluminum Co. owned by Kaiser and Reynolds reached an agreement on the price of electrical power for the Volta smelter. However, the 200 000 tpy smelter remains closed due to a shortage of electricity. Also in 1984, the U.S.S.R. and Ghana signed an agreement whereby the U.S.S.R. will aid Ghana to develop a deposit of bauxite at Kibi, in the eastern part of the country.

In Japan, the government is continuing its efforts to trim the size of its primary aluminum capacity. The most recent announced objective is to reduce primary aluminum capacity from 700 000 t to 350 000 t during the three year period from 1985 to 1987. Japanese smelting capacity in the late 1970s was approximately 1.6 million tpy.

In line with the latest goal, Nippon Light Metal Co. Ltd. announced that it would close its Tomakomai smelter on April 1, 1985, while Sumitomo Aluminum Smelting Co. Ltd. said that it would close its Toyo smelter early in the new year. The two smelters have a combined capacity of about 171 000 tpy. In order to compensate companies for the permanent cutback in capacity, the government of Japan will limit the import duty for the first 350 000 t of aluminum imported in 1985 to 1 per cent. Imports in excess of this level will be subject to the normal 9 per cent rate of duty.

In Europe, the major aluminum producers including Aluminium Pechiney of France; Vereinigte Aluminium-Werke (VAW) of West Germany; Norsk Hydro, Elkem and ASV of Norway; Schweizerische Aluminium AG (Alusuisse); and Alluminio Italia announced significant temporary cutbacks in primary aluminum production during the second half of 1984. In addition, a national plan for the aluminum industry in Italy was unveiled at the end of 1984 which includes the permanent closure of the Balzano smelter in 1985 and the Porto Marghera smelter in 1986. However, Norsk Hydro announced at the end of 1984 that it was proceeding with a 50 000 tpy capacity increase to its Karmoy smelter and was also planning to increase the capacity of the Sor Norge aluminum smelter which is jointly-owned with Alusuisse.

## PRICES

Monthly average prices on the LME which had risen to a high of 73.2 cents (U.S.) per pound in September 1983 declined through the first half of 1984 to reach 45.8 cents in September. This was followed by a small improvement during which prices climbed to 55 cents by the middle of November. For the remainder of the year prices eased once again with aluminum, at the end of December, trading at 47 cents (U.S.) per pound.

The usefulness of producer list prices was dealt a severe blow in 1984 with the announcement by Alcan that it was withdrawing its international list price. The AWP price had served as a basis for various world aluminum supply contracts including past Japanese contracts with Indonesia and Venezuela but had not been relevant for the past few years.

During 1984, Pechiney began publishing its PIP index which plots the movement in aluminum prices which have been achieved on Pechiney's own sales to independent customers. According to Pechiney the index is intended to be a pricing system which avoids the volatility of day to day LME pricing and also the lack of market applicability inherent with producer list prices.

Late in 1984, the International Bauxite Association announced that it was recommending a minimum $US 35 per t cif for base-grade bauxite in 1985 and a minimum price of $US 225 per t cif for metallurgical base-grade alumina. Prices in 1984 for high quality bauxite were about $25-30 per t fob while the price of alumina was about $120 to $140 per t fob.

## USES

Aluminum has various characteristics including low density, high strength and corrosion resistance, which makes it suitable for use in alloyed and unalloyed forms, in a wide variety of products. In the building and construction industry, major uses for aluminum include residential siding; window and door frames; screens; awnings and canopes; bridge, steel and highway equipment and mobile homes. In the transportation sector, aluminum is widely used in the manufacture of buses, trucks, trailers and semi-trailers and is the principal metal in aircraft. In addition, aluminum is being increasingly used in passenger cars as manufacturers move to reduce the weight of their vehicles. Since 1974 the amount of aluminum used in a typical American car has risen from 70 lbs to around 135 lbs in 1983.

In the electrical field, aluminum largely replaced copper in the wiring and power transmission in the 1960s. While aluminum has maintained the market for power transmission applications, local restrictions and consumer resistance have lessened the demand for aluminum in electrical wiring. Aluminum has however gained acceptance in various communications and computer applications.

The fastest growing market for aluminum in the 1970s was containers and packaging, including cans and foil. However, with increased recycling of aluminum cans, demand growth has slowed somewhat in recent years.

Aluminum is used to produce consumer goods and is also used in the manufacture of a wide variety of machinery and equipment, and in several important applications in the chemical industry.

## OUTLOOK

Aluminum is considered to be entering the mature stage of its demand life cycle, since there appears to be no major new applications for the metal that should dramatically boost demand. Furthermore, increased competition from plastics, composite materials, high strength steels will limit aluminum demand. Consequently it is expected that aluminum demand will grow at an average annual rate of between 2 and 2.5 per cent in the next decade, compared to a 6.5 per cent rate of growth achieved during the 1965-1980 period.

Although the amount of aluminum used in beverage cans is expected to grow outside the United States, the growth of demand for primary aluminum from this sector within the large U.S. market will begin to decline. Reasons for this include greater recovery rate for used beverage containers, the production of thinner walled cans, and increased competition from steel cans and plastic cans which are expected to be in production in 1985. Efforts to develop a commercially acceptable aluminum food can have not yet proven successful.

Although, aluminum prices are expected to remain competitive with copper in the electrical field, aluminum is not expected to re-establish itself in the electrical wiring market.

While there has been much publicity concerning the potential application of newly developed aluminum lithium alloys in the aerospace industry, the success of these alloys will simply halt the erosion of market share to new nonmetallic materials.

Although faced with rigorous competition from other lightweight materials, aluminum will be increasingly used by the automobile industry. New applications for aluminum include radiators, heater cores, airconditioner units, exterior trim, engine blocks, cylinder heads, transmissions and wheels.

Aluminum prices are expected to recover in 1985 to about 55-60 cents (U.S.) as aluminum producers continue to implement production cutbacks. In 1986, the price should increase to about 65 cents (U.S.). Longer-term prices are not expected to rise significantly in view of the expected continued strength of the U.S. dollar and also due to a chronic oversupply situation which is likely to persist for the rest of the decade. This will arise because of a probable slow permanent closure rate for high cost capacity in the United States and Europe and also to new smelter construction which will continue in Canada, Australia, Brazil and in other developing nations. However, with the gradual replacement of old inefficient smelters, the average cost of producing aluminum, which has already dropped, will continue to fall.

Although the large integrated aluminum producers which once completely dominated the industry will remain important, the restructuring of the industry will result in an increased number of independent producers and an increased equity participation of governments.

Canada is currently a low, if not the lowest, cost aluminum producer in the world. Canada's production costs are estimated at 43 cents (U.S.) per pound while the United States and Japan are the most expensive at 64 cents. With large quantities of inexpensive hydro-electric power available and potential for substantially more, Canada should significantly increase its share of world aluminum production in the next decade.

## PRICES

| Month | U.S. Market | LME Cash |
|---|---|---|
| | ¢ U.S./pound | |
| January | 76.1 | 70.2 |
| February | 73.3 | 67.8 |
| March | 71.6 | 66.0 |
| April | 68.2 | 62.1 |
| May | 64.7 | 58.5 |
| June | 63.2 | 57.8 |
| July | 56.1 | 52.7 |
| August | 54.4 | 51.5 |
| September | 48.4 | 45.8 |
| October | 50.1 | 46.6 |
| November | 55.1 | 52.2 |
| December | 51.4 | 49.7 |
| 1984 Average | 61.1 | 56.5 |

Source: Metals Week.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| **CANADA** | | | | | |
| 32910-1 | Bauxite | free | free | free | free |
| 35301-1 | Aluminum pigs, ingots, blocks, notch bars, slabs, billets, blooms and wire bars, per pound | free | .5¢ | 5¢ | free[1] |
| 35302-1 | Aluminum bars, rods, plates, sheets, strips, circles, squares, discs and rectangles | free | 2.3 | 9 | free |
| 35303-1 | Aluminum channels, beams, tees and other rolled, drawn or extruded sections and shapes | free | 10.3 | 30 | free |
| 35305-1 | Aluminum pipes and tubes | free | 10.3 | 30 | free |
| 92820-1 | Aluminum oxide and hydroxide; artificial corundum (this tariff includes alumina) | free | free | free | free |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 35301-1 | .5¢ | .4¢ | .3¢ | .1¢ | free |
| 35302-1 | 2.3 | 2.2 | 2.2 | 2.1 | 2.1 |
| 35303-1 | 10.3 | 9.7 | 9.1 | 8.6 | 8.0 |
| 35305-1 | 10.3 | 9.7 | 9.1 | 8.6 | 8.0 |
| 92820-1 | | | | | |

| UNITED STATES (MFN) | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 417.12 | Aluminum compounds: hydroxide and oxide (alumina) | Remains free | | | | |
| 601.06 | Bauxite | Remains free | | | | |
| 618.01 | Unwrought aluminum in coils, uniform cross section not greater than 0.375 inch, per pound | 2.9 | 2.8 | 2.8 | 2.7 | 2.6 |
| 618.02 | Other unwrought aluminum, excluding alloys, per pound | 0.5¢ | 0.3¢ | 0.2¢ | 0.1¢ | free |
| 618.04 | Aluminum silicon, per pound | 2.3 | 2.3 | 2.2 | 2.2 | 2.1 |
| 618.06 | Other aluminum alloys, per pound | 0.5¢ | 0.3¢ | 0.2¢ | 0.1 | free |
| 618.10 | Aluminum waste and scrap, per pound | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |

Sources: Customs Tariff, Revenue Canada; Tariff Schedules of the United States Annotated 1983, USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241.

[1] Pending passage by Parliament of the Notice of Ways and Means Motion tabled on November 12, 1981.

TABLE 1. CANADA, ALUMINUM PRODUCTION AND TRADE, 1982-84

| | 1982 | | 1983P | | 1984 | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Production** | 1 064 795 | .. | 1 091 213 | .. | 924 213 | .. |
| **Imports** | | | | | | |
| Bauxite ore | | | | | (Jan.-Sept. 1984) | |
| Brazil | 1 316 216 | 49,561 | 1 263 507 | 47,225 | 1 071 124 | 42,065 |
| Guinea | 762 663 | 23,735 | 614 095 | 19,263 | 142 535 | 7,589 |
| Guyana | 387 973 | 13,617 | 337 482 | 11,574 | 415 156 | 14,111 |
| Surinam | 66 903 | 7,462 | 57 178 | 7,363 | 4 057 | 644 |
| United States | 20 327 | 3,618 | 24 829 | 4,499 | 33 206 | 5,544 |
| Australia | 17 623 | 1,726 | 17 923 | 1,845 | 44 653 | 5,933 |
| People's Republic of China | 3 057 | 409 | 14 803 | 900 | 23 669 | 2,204 |
| Other countries | - | - | 93 | 11 | 14 477 | 527 |
| Total | 2 574 762 | 100,128 | 2 329 910 | 92,680 | 1 748 877 | 78,616 |
| Alumina | | | | | | |
| Jamaica | 391 815 | 112,177 | 423 782 | 93,542 | 404 545 | 88,831 |
| Japan | 194 368 | 48,561 | 261 340 | 57,705 | 210 543 | 49,544 |
| Australia | 257 481 | 60,190 | 256 852 | 54,308 | 217 622 | 50,048 |
| West Germany | 56 | 30 | 108 186 | 29 026 | 110 260 | 35,269 |
| United States | 95 562 | 32,281 | 12 822 | 6,133 | 30 088 | 11,641 |
| Other countries | - | - | 199 | 135 | 26 057 | 4,671 |
| Total | 939 282 | 253,239 | 1 063 181 | 240,849 | 999 115 | 240,004 |
| Aluminum and aluminum alloy scrap | 36 757 | 31,758 | 54 666 | 53,984 | 48 579 | 51,880 |
| Aluminum paste and aluminum powder | 1 675 | 4,725 | 1 625 | 5,873 | 1 492 | 5,768 |
| Pigs, ingots, shot, slabs, billets, blooms and extruded wire bars | 24 379 | 40,971 | 30 581 | 55,361 | 34 427 | 68,546 |
| Castings | 1 129 | 10,080 | 729 | 8,956 | 709 | 10,068 |
| Forgings | 616 | 10,931 | 456 | 7,187 | 577 | 9,999 |
| Bars and rods, nes | 3 453 | 9,617 | 3 250 | 10,046 | 4 959 | 15,337 |
| Plates | 5 930 | 18,926 | 6 010 | 17,906 | 7 234 | 24,410 |
| Sheet and strip up to .025 inch thick | 13 241 | 37,903 | 18 894 | 54,335 | 12 669 | 42,124 |
| Sheet and strip over .025 inch up to .051 inch thick | 7 629 | 23,777 | 12 356 | 37,693 | 10 731 | 38,769 |
| Sheet and strip over .051 inch up to .125 inch thick | 34 702 | 79,493 | 44 922 | 100,942 | 71 751 | 183,826 |
| Sheet over .125 inch thick | 27 957 | 62,796 | 27 618 | 61,141 | 29 669 | 81,212 |
| Foil or leaf | 501 | 1,661 | 666 | 2,248 | 683 | 2,701 |
| Converted aluminum foil | .. | 10,398 | .. | 11,169 | | 11,495 |
| Structural shapes | 1 656 | 7,120 | 2 595 | 9,775 | 2 119 | 8,915 |
| Pipe and tubing | 1 160 | 5,175 | 1 430 | 6,267 | 1 179 | 5,791 |
| Wire and cable, not insulated | 7 295 | 4,921 | 1 459 | 4,414 | 1 019 | 3,725 |
| Aluminum and aluminum alloy fabricated materials, nes | .. | 48,536 | .. | 56,093 | | 51,199 |
| Total aluminum imports | .. | 408,788 | .. | 503,390 | | 615,765 |
| **Exports** | | | | | | |
| Pigs, ingots, shot, slabs, billets, blooms and extruded wire bars | | | | | | |
| United States | 418 662 | 658,945 | 581 123 | 993,205 | 470 084 | 934,452 |
| Japan | 161 160 | 208,737 | 140 351 | 218,739 | 62 638 | 148,839 |
| People's Republic of China | 168 017 | 190,223 | 98 989 | 139,105 | 29 996 | 50,740 |
| Hong Kong | 46 323 | 64,488 | 22 492 | 38,154 | 4 861 | 9,300 |
| Thailand | 6 264 | 9,267 | 16 992 | 28,799 | 5 899 | 12,172 |
| West Germany | 7 820 | 12,104 | 11 816 | 22,452 | 15 640 | 32,775 |
| Malaysia | 3 119 | 4,555 | 11 059 | 19,629 | 5 142 | 10,418 |
| Israel | 5 758 | 8,705 | 6 706 | 11,566 | 3 903 | 8,293 |
| South Korea | 5 269 | 7,861 | 5 808 | 10,644 | 95 | 208 |
| Taiwan | 11 992 | 14,616 | 4 568 | 6,743 | 1 999 | 3,542 |
| Colombia | 3 600 | 4,887 | 3 998 | 6,711 | 1 993 | 3,877 |
| Other countries | 58 381 | 85,387 | 21 501 | 34,676 | 6 606 | 13,691 |
| Total | 896 365 | 1,269,775 | 925 403 | 1,530,423 | 628 856 | 1,228,307 |

**TABLE 1.** (cont'd)

| | 1982 | | 1983P | | 1984 | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes)<br>(Jan.-Sept.) | ($000) |
| **Exports** (cont'd) | | | | | | |
| Castings and forgings | | | | | | |
| United States | 4 870 | 39,055 | 7 140 | 52,173 | 5 865 | 47,862 |
| Total | 5 241 | 50,522 | 7 692 | 64,404 | 6 369 | 56,446 |
| Bars, rods, plates, sheets and circles | | | | | | |
| United States | 20 901 | 54,968 | 38 671 | 97,816 | 55 024 | 157,165 |
| Total | 25 456 | 66,698 | 45 365 | 111,132 | 58 838 | 168,155 |
| Foil | | | | | | |
| United States | 612 | 2,000 | 1 337 | 4,495 | 1 253 | 4,950 |
| Total | 964 | 3,184 | 1 443 | 4,895 | 1 264 | 5,002 |
| Fabricated materials, nes | | | | | | |
| United States | 7 667 | 29,453 | 8 843 | 27,999 | 8 493 | 29,482 |
| Total | 10 540 | 38,185 | 10 606 | 33,371 | 10 072 | 35,365 |
| Ores and concentrates | | | | | | |
| United States | 23 000 | 10,041 | 40 347 | 17,804 | 36 287 | 16,869 |
| Total | 27 746 | 13,142 | 44 993 | 20,427 | 39 461 | 18,889 |
| Scrap | | | | | | |
| United States | 53 394 | 56,779 | 71 925 | 84,859 | 71 707 | 98,474 |
| Total | 62 610 | 64,959 | 80 911 | 95,572 | 75 337 | 103,209 |
| Total aluminum exports | .. | 1,506,465 | .. | 1,860,224 | .. | 1,615,373 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; - Nil; .. Not available; nes Not elsewhere specified.

## TABLE 2. CANADA, CONSUMPTION OF ALUMINUM AT FIRST PROCESSING STAGE, 1980-82

| | 1980 | 1981 | 1982 |
|---|---|---|---|
| | | (tonnes) | |
| **Castings** | | | |
| Sand | 1 788 | 1 397 | 1 241 |
| Permanent mould | 8 500 | 9 358 | 9 541 |
| Die | 20 452 | 18 777 | 19 629 |
| Other | 135 | - | - |
| Total | 30 875 | 29 532 | 30 411 |
| **Wrought products** | | | |
| Extrusions, including tubing | 94 129 | 89 057 | 70 116 |
| Sheet, plate, coil and foil | 112 890 | 138 905 | 99 633 |
| Other wrought products (including rod, forgings and slugs) | 83 001 | 71 210 | 67 638 |
| Total | 290 020 | 299 172 | 237 387 |
| **Other uses** | | | |
| Destructive uses (deoxidizer), non-aluminum base alloys, powder and paste | 8 505 | 8 285 | 5 725 |
| Total consumed | 329 400 | 336 989 | 273 523 |
| **Secondary aluminum**[1] | 39 723 | 48 453 | 35 938 |

| | Metal entering plant | | | On hand December 31 | | |
|---|---|---|---|---|---|---|
| | 1980 | 1981 | 1982 | 1980[2] | 1981[3] | 1982[3] |
| Primary aluminum ingot and alloys | 297 515 | 292 100 | 225 156 | 92 659 | 83 088 | 78 191 |
| Secondary aluminum | 27 691 | 31 791 | 35 255 | 3 447 | 1 859 | 2 090 |
| Scrap originating outside plant | 42 166 | 46 305 | 44 271 | 16 037 | 1 596 | 1 483 |
| Total | 367 372 | 370 196 | 304 682 | 112 143 | 86 543 | 81 764 |

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[1] Secondary metal totals not included in above consumptions. [2] Derived from opening inventory plus metal entering plant minus consumption, minus secondary aluminum. [3] Actual numbers reported by consumers.
- Nil.

### TABLE 3. CANADA, ALUMINUM SMELTER CAPACITY

(as of December 31, 1984)

| | Annual tonnes |
|---|---|
| Aluminum Company of Canada, Limited | |
| Quebec | |
| Grande Baie | 171 000 |
| Jonquière | 432 000 |
| Isle-Maligne | 73 000 |
| Shawinigan | 84 000 |
| Beauharnois | 47 000 |
| British Columbia | |
| Kitimat | 268 000 |
| Total Alcan capacity | 1 075 000 |
| Canadian Reynolds Metals Company, Limited | |
| Quebec | |
| Baie Comeau | 158 760 |
| Total Canadian capacity | 1 233 760 |

Source: Compiled from company reports by Energy, Mines and Resources Canada.

### TABLE 4. ESTIMATED WORLD PRODUCTION OF BAUXITE, 1982 AND 1983

| | 1982 | 1983P |
|---|---|---|
| | (million tonnes) | |
| Australia | 23.6 | 24.5 |
| Guinea | 11.8 | 13.0 |
| Jamaica | 8.2 | 7.7 |
| Brazil | 4.2 | 5.2 |
| Surinam | 3.3 | 3.0 |
| Greece | 2.9 | 2.4 |
| India | 1.9 | 1.8 |
| Guyana | 1.8 | 1.1 |
| France | 1.7 | 1.7 |
| Other market economy countries | 7.4 | 6.6 |
| Total market economy countries | 66.8 | 67.0 |
| Central economy countries[1] | 15.0 | 15.0 |
| World total | 78.1 | 78.6 |

Source: World Bureau of Metal Statistics.
[1] Includes Yugoslavia.
P Preliminary.

### TABLE 5. ESTIMATED NON-COMMUNIST WORLD PRODUCTION OF ALUMINA, 1982 AND 1983

| | 1982 | 1983 | 1st Qtr 1984 | 2nd Qtr 1984 | 3rd Qtr 1984 |
|---|---|---|---|---|---|
| | (million tonnes) | | | | |
| Europe[1] | 4.46 | 4.35 | 1.24 | 1.34 | 1.35 |
| Africa | 0.58 | 0.56 | 0.13 | 0.13 | 0.14 |
| Asia | 1.81 | 1.89 | 0.50 | 0.53 | 0.53 |
| North America | 5.27 | 5.07 | 1.40 | 1.46 | 1.51 |
| South America | 3.48 | 4.17 | 1.07 | 1.05 | 1.20 |
| Australasia | 6.63 | 7.31 | 2.00 | 2.14 | 2.32 |
| Total | 22.23 | 23.35 | 6.34 | 6.66 | 7.04 |
| of which nonmetallic uses | 1.97 | 2.06 | 0.53 | 0.62 | 0.59 |

Source: International Primary Aluminum Institute.
[1] Excludes Yugoslavia.

## TABLE 6. WORLD PRIMARY ALUMINUM PRODUCTION AND CONSUMPTION, 1982 AND 1983

| | Production | | Consumption | |
|---|---|---|---|---|
| | 1982 | 1983P | 1982 | 1983P |
| | (000 tonnes) | | | |
| United States | 3 274.0 | 3 353.0 | 3 648.0 | 4 209.9 |
| Europe[1] | 3 309.3 | 3 311.3 | 3 501.0 | 3 589.5 |
| Japan | 350.7 | 255.9 | 1 636.8 | 1 801.2 |
| Canada | 1 064.8 | 1 091.2 | 273.5 | 337.5 |
| Australia and New Zealand | 548.1 | 695.2 | 242.1 | 221.7 |
| Asia (excluding Japan and People's Republic of China) | 675.1 | 717.3 | 774.6 | 775.6 |
| Africa | 501.2 | 433.4 | 187.4 | 170.1 |
| America (excluding United States and Canada) | 796.1 | 944.5 | 521.8 | 514.6 |
| Sub-total | 10 519.3 | 10 801.8 | 10 785.2 | 11 620.1 |
| Central economy countries | 3 437.4 | 3 486.1 | 3 501.4 | 3 528.3 |
| Total | 13 956.7 | 14 287.9 | 14 286.6 | 15 148.4 |

Sources: American Bureau of Metal Statistics; Energy, Mines and Resources Canada.
[1] Excludes Yugoslavia.
P Preliminary.

# Antimony

J. BIGAUSKAS

## INTRODUCTION

Antimony is a silver-white brittle metal generally found as the sulphide mineral stibnite $Sb_2S_3$, or its oxidized equivalents but may also be present in trace amounts in lead ores, or in association with gold, tungsten and silver ores. High-grade lump ores are separated by hand cobbing - a relatively labour intensive method - while more disseminated ores are selectively processed by flotation and sold as concentrates typically containing 60 per cent antimony by weight. Antimony in antimonial lead alloys is also widely recycled from lead-acid battery scrap.

Major mine producers in the non-socialist world are Bolivia and the Republic of South Africa, while major producers in the socialist world are the People's Republic of China and the U.S.S.R.

## CANADIAN DEVELOPMENTS

Since 1981 primary antimony output in Canada has been mostly a byproduct of the refining of lead. Cominco Ltd., which operates a lead smelter and refinery at Trail, British Columbia, produces a primary antimonial-lead product. Trail produces most of its antimonial lead from lead concentrates obtained from Cominco's Sullivan mine at Kimberley, British Columbia. Other sources are lead-silver ores and concentrates shipped to Trail by custom shippers. The lead bullion produced from smelting of these ores and concentrates contains a small amount of antimony which subsequently collects either in anode residues from the electrolytic refining of the lead bullion or in furnace drosses. These residues and drosses are treated to yield antimonial-lead alloy, to which refined lead may be added to produce marketable products of the required grade.

Slag containing antimony is removed by oxidation from lead bullion at Brunswick Mining and Smelting Corporation's pyrometallurgical lead refinery at Belledune, New Brunswick. The slag, which also contains arsenic, is skimmed off and fed into an antimony reverberatory furnace along with some coke. From this, lead bullion is returned to the circuit while antimony - containing slag is stockpiled for sale. This product is sold without further upgrading. Brunswick's No. 12 zinc-lead-silver-copper mine near Bathurst, New Brunswick provides lead concentrate feed which contains a small amount of antimony.

Production of primary antimony in Canada totalled 510 t in 1984, some 25 t more than in 1983. Antimony contained in antimonial lead is also recycled by secondary lead smelters which process scrap lead-acid batteries.

Operations at the original orebody of Consolidated Durham Mines & Resources Limited (renamed Durham Resources Inc. in 1984) near Fredericton, New Brunswick ceased in May 1981 when antimony reserves in the Hibbard orebody were exhausted. The company produced antimony concentrates which were of premium quality and found ready markets in the United States and Europe. An extensive diamond drilling program in 1980 and 1981 to search for more ore at deeper horizons outlined an antimony-bearing zone containing an estimated 774 000 t averaging 4.15 per cent antimony. This zone appears to be the downward extension of the mined zone.

Durham completed dewatering of the mine in September and began deepening the inclined shaft from 240 m to 430 m. The rehabilitation of the mine is expected to cost \$Cdn 3.7 million. Production, which is targeted for the third-quarter of 1985, will be about 360-390 tpd. A feasibility study is being conducted to evaluate the possibility of adding a roaster-smelter operation at a capital cost of \$Cdn 3-4 million.

Canadian consumption of antimony in 1983 was 217 t. In 1984, consumption is expected to be slightly lower.

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## WORLD DEVELOPMENTS

Major producers of antimony ores and concentrates are Bolivia and the Republic of South Africa, with some 40 and 25 per cent of western world production, respectively. Other producers include Mexico, Thailand, Turkey, Yugoslavia, Austria and the United States which collectively account for another 30 per cent of mine production in the western world. Large quantities of antimony metal are also exported by the People's Republic of China to consumers around the world, including other socialist nations. The Xikuangshan mine in Hunan province is the largest antimony producer. Antimony metal in three grades is supplied as well as antimony oxides and crude oxides.

In 1983, western world mine production was 26 235 t antimony content (World Metal Statistics). Dropping production in Bolivia during 1984 is expected to continue the trend toward declining western world mine production since 1980. An estimated 24 000 t was produced in 1984.

In Bolivia widespread strikes and difficulties in obtaining foreign currency were cited as reasons for a decline in mine output by Bolivia's major producer, Empresa Minera Unificado S.A. (EMUSA). Estimated production in 1984 was expected to be 30 per cent lower than in 1983. The company reopened its Caracota mine temporarily but in June it was reported that the mine would be closed for at least three months to deepen the shaft and develop reserves.

Empresa Mineral Bernal Hermanos proceeded with a planned expansion of its antimony smelter near Tupiza. Four more rotary furnaces were to be installed in 1984 along with a new cupel furnace for fuming metal to oxide. The new equipment will upgrade crude oxide to higher quality products. The expansion of the Hermanos smelter also required the development of the 1 500 tpy Rosa de Oro mine.

The state-owned smelter of Empresa Nacional de Fundiciones (ENAF) was expected to raise overall production of antimony metal and oxides by 2 000 t in 1984.

As a result of Bolivian developments at the mining, smelting and refining stages, exports of antimony in concentrates were expected to decline to 8 500 to 9 000 t in 1984 and to 7 200 t or less in 1985. Production and sales of antimony metal and oxides are expected to increase.

A lead-silver smelter employing Kivcet technology built at Karachipampa in Potosi did not operate during 1984 due to lack of feed. The joint venture project by Comibol (Corporacion Minera de Bolivia) and ENAF was designed with a capacity of 24 000 tpy of lead, 2 000 tpy of antimony with additional amounts of zinc, silver and tin.

With the tightening of Bolivian concentrate and ore exports in 1984 the non-socialist world's second largest producer, the Republic of South Africa, found more opportunities to export its own products. Sales in the first half of 1984 depleted Consolidated Murchison Ltd.'s (CML) stocks of concentrate. Current production - about 20 000 tpy of concentrate - was expected to supply remaining demand. Generally most of CML's mine output is processed at Antimony Products (Pty.) Ltd.'s antimony trioxide plant.

A new producer, Cia Minera Norcro, commenced production of oxide ore and lump sulphides from an open-pit located in the Honduras near Santa Rita. Production began in January. Full capacity (300 tpm) is not expected to be reached until mid-1985 or 1986. The ore is processed further to antimony oxide by Anzon America Inc. in the United States.

As part of its usual production cycle, Metallurgie Hoboken-Overpelt SA/NV of Belgium resumed production of antimony metal from September until January or February 1985. Hoboken's lead smelter/antimony plant has the capacity to produce 4 000 tpy of antimony mostly from imported complex lead and lead/copper concentrates and intermediate residues and slags which contain antimony. Pennarroya S.A. produces sodium antimonate and antimony oxide as byproducts from its lead smelting operation in France. A large proportion of antimony in Europe is recycled by secondary lead smelters from lead-acid battery scrap. Battery alloys on average contain higher amounts of antimony in Europe than in North America where calcium-lead alloys now dominate the automotive battery market.

In Japan most antimony in metallic form is produced as a byproduct of lead bullion refining or recycled in lead-acid battery alloy metal. Mine production of antimony ores ceased in 1971, and as a result production of antimony metal dropped sharply. Japan relies primarily upon the People's Republic of China for metal and Bolivia for antimony concentrates. Antimony trioxide is then produced from these materials at several plants.

Although the United States is not a large mine producer of antimony, production of antimony trioxide and antimony salts from raw materials, and recycling of antimony in antimonial lead are very significant. ASARCO Incorporated produces antimony oxide at its Omaha lead refinery. The refinery is fed by two smelters which process imported and domestic complex lead concentrates and other materials. Recycling of battery scrap accounts for 50 per cent of apparent United States domestic antimony consumption and some 90 per cent of secondary antimony is recovered as antimonial lead. Antimony metal is imported mainly from Bolivia and the People's Republic of China. Ores and concentrates are mostly from Bolivia and Mexico, and oxides are purchased mainly from the Republic of South Africa.

Beginning December 6, 1984 the United States General Services Administration (GSA) commenced monthly domestic sales of a maximum of 135 t of antimony metal from the strategic stockpile. In 1983, 900 t was offered at one auction. The staggered sale of antimony in 1984 was planned to minimize effects on the market.

## PRICES

The New York Dealer price for antimony metal as quoted by "Metals Week" rose from a monthly average of $US 1.26 per pound in January to $1.65 per pound in September and dropped to $1.40 per pound average in December, 1984. The annual average price in 1984 was $US 1.51 per pound, much higher than 1983s $0.91 average.

The price of clean concentrates and lump sulphides (60 per cent Sb) also as reported in "Metal Bulletin", rose from $US 16.50-17.25 per t Sb and $16.75-17.50 per t to $US 27.75-29.00 and $28.75-31.00 respectively, by the end of the year.

## USES

Antimony is used principally in alloyed form and in the form of oxides. Antimony hardens and strengthens lead and inhibits chemical corrosion. These characteristics created a large use for the metal in antimonial-lead storage batteries. However, the introduction of the low antimonial-lead battery and the lead-calcium battery has reduced this application particularly in North America. Antimonial-lead alloys are also used for power transmission and communications cable sheathing, type metal, solder, ammunition, chemical pump and pipe linings, tank linings, sheets and antifriction bearings.

Antimony trioxide, pentoxide or oxychloride, and sodium antimonate are used as fire retardants in plastics, textiles and rubber. This end use is now the largest for antimony.

Antimony trioxide or sodium antimonate may also be used as refining and decolouring agents in certain types of glass. Sodium antimonate is normally used in the manufacture of television screens. Antimony trioxide is also used in the manufacturing of white pigments. Pentasulphide ($Sb_2S_5$) is a vulcanizing agent for the production of red rubber compounds. Burning antimony sulphide creates a dense white smoke for visual control in sea markers, in signaling and in fireworks.

High-purity metal is used in the production of indium antimonide and aluminum antimonide intermetallic materials for semiconductors.

## OUTLOOK

Growth in the antimony-based pigment and fire-retardant markets is projected by manufacturers at 4 to 6 per cent annually in the next three to four years. On the other hand, demand for antimony metal in lead-acid batteries is expected to stagnate as battery alloy compositions in North America, Europe and Japan continue to shift, as a whole, to calcium-based alloys. Despite the poor outlook for the battery market, one Bolivian producer estimates that demand for antimony in general will continue to grow at 3 to 4 per cent per annum.

Nevertheless, with healthy growth in consumption and with the continuing trend of further processing by major mine producers such as Bolivia, demand for ores and concentrates and other materials may improve even more. The re-opening of Canada's sole antimony ore producer will likely depend upon favourable conditions in this segment of the market.

**TARIFFS**

| Item No. | | British Preferential | General Preferential | Most Favoured Nation | General |
|---|---|---|---|---|---|
| | | | % | | |
| CANADA | | | | | |
| 33000-1 | Antimony or regulus of, not ground, pulverized or otherwise manufactured | free | free | free | free |
| 33502-1 | Antimony oxides | free | free | 6.3 | 25 |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | % | | |
| 33502-1 | 6.3 | 4.7 | 3.1 | 1.6 | free |

| UNITES STATES (MFN) | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (¢ per pound) | | |
| 601.03 | Antimony ore | Remains free | | | | |
| 632.02 | Antimony metal unwrought etc. (Duty on waste and scrap temporarily suspended) | 0.5 | 0.4 | 0.3 | 0.1 | free |

| EUROPEAN ECONOMIC COMMUNITY (MFN) | | 1983 |
|---|---|---|
| 26.01 | Antimony ore | free |
| 81.04 | 1. Antimony unwrought waste and scrap | free |
| | 2. Antimony, other | 8 |

Sources: The Customs Tariff 1983, Revenue Canada - Customs and Excise Schedules of the United States Annotated 1983, USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 25, No. L318, 1982.

## TABLE 1. CANADA, ANTIMONY PRODUCTION AND IMPORTS, 1983 AND 1984 AND CONSUMPTION, 1982 AND 1983

| | 1983 | | 1984P | |
|---|---|---|---|---|
| | (kilograms) | ($000) | (kilograms) | ($000) |
| **Production** | | | | |
| Ontario | .. | 72 | | .. |
| New Brunswick | .. | 589 | .. | 827 |
| British Columbia | .. | 1,432 | .. | 2,187 |
| Total | .. | 2,093 | 510 000 | 3,014 |
| **Imports** | | | | |
| Antimony oxide | | | (Jan. - Sept.) | |
| United Kingdom | 576 000 | 2,132 | 576 000 | 2,243 |
| United States | 263 000 | 979 | 253 000 | 1,115 |
| Belgium-Luxembourg | 141 000 | 410 | 93 000 | 387 |
| France | 21 000 | 48 | 20 000 | 74 |
| Total | 1 001 000 | 3,570 | 1 001 000 | 3,819 |

| | 1982 | 1983P |
|---|---|---|
| **Consumption**[1] | (kilograms) | |
| Antimony metal used for, or in the production of: | | |
| Antimonial lead | 54 754 | 80 561 |
| Babbit | 12 329 | 14 694 |
| Type metal | 5 686 | 6 843 |
| Solder | 4 765 | 5 952 |
| Other commodities | 83 500 | 109 302 |
| Total | 161 034 | 217 352 |
| Held by consumers on December 31[2] | 39 799 | 26 106 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Antimony content of primary and secondary antimonial-lead alloys. [2] Available data, as reported by consumers.
P Preliminary; .. Not available due to confidentiality.

## TABLE 2. CANADA, CONSUMPTION AND CONSUMERS' STOCKS OF ANTIMONY[1], 1970, 1975, AND 1978-83

| | Consumption | | On hand at end of year | |
|---|---|---|---|---|
| | Antimony metal | Antimonial-lead alloy[2] | Antimony metal | Antimonial-lead alloy[2] |
| | (kilograms) | | | |
| 1970 | 518 007 | 635 212 | 131 501 | 91 563 |
| 1975 | 454 164 | 723 155 | 116 760 | 170 478 |
| 1978 | 347 906 | 1 000 732 | 101 814 | 91 049 |
| 1979 | 463 423 | 931 990 | 39 976 | 87 473 |
| 1980 | 369 732 | 643 983 | 42 389 | 51 405 |
| 1981 | 209 829 | 691 180 | 35 105 | 151 400 |
| 1982 | 161 034 | 605 502r | 39 799 | 76 979 |
| 1983 | 217 352 | 560 705 | 26 106 | 130 104 |

Sources: Statistics Canada; Energy, Mines and Resources, Canada.
[1] Available data, as reported by consumers. [2] Antimony content of primary and secondary antimonial-lead alloys.
r Revised.

### TABLE 3. WORLD MINE PRODUCTION OF ANTIMONY, 1982-84

| | 1982 | 1983 | 1984 (Jan-June) |
|---|---|---|---|
| | | (tonnes) | |
| **Europe** | | | |
| Austria | 670 | 970 | 394 |
| France | 532 | 111 | - |
| Italy | 339 | - | - |
| Spain | 461 | 489 | 247 |
| Yugoslavia | 1 517 | 950 | 576 |
| **Africa** | | | |
| Morocco | 845 | 454 | 226 |
| South Africa | 9 134 | 6 302 | 3 152 |
| Zimbabwe | 233 | 143 | 72 |
| **Asia** | | | |
| Malaysia | 144 | 133 | 66 |
| Thailand | 972 | 1 740 | 870 |
| Turkey | 1 237 | 1 059 | 530 |
| **America** | | | |
| Bolivia | 13 612 | 9 951 | .. |
| Mexico | 1 565 | 2 519 | 1 258 |
| Peru | 724 | 375 | 186 |
| United States | 456 | 760 | .. |
| Other | 961 | 964 | .. |
| **Australia** | | | |
| Australia | 1 146 | 528 | 264 |
| Total | 33 408 | 26 235 | .. |
| **Other** | | | |
| China, P.R. | 12 000 | 13 000 | .. |
| Czechoslovakia | 700 | 900 | .. |
| U.S.S.R. | 6 500 | 6 500 | .. |
| Other Europe | 500 | 500 | .. |
| **World Total** | 53 108 | 47 135 | .. |

Sources: World Metal Statistics
- Nil. .. Not available.

### TABLE 4. INDUSTRIAL CONSUMPTION OF PRIMARY ANTIMONY IN THE UNITED STATES BY PRODUCT PRODUCED, 1982 AND 1983

| | 1982 | 1983 |
|---|---|---|
| | (tonnes) | |
| **Metal Products** | | |
| Ammunition | 267 | 159 |
| Antimonial lead | 719 | 835 |
| Bearing metal and bearings | 130 | 130 |
| Cable covering | 23 | 28 |
| Castings | 8 | 8 |
| Collapsible tubes and foil | 1 | W |
| Sheet and pipe | 24 | 39 |
| Solder | 112 | 140 |
| Type metal | 10 | 9 |
| Other | 61 | 64 |
| **Non-Metal Products** | | |
| Ammunition primers | 18 | 15 |
| Fireworks | 5 | 4 |
| Flame-retardants | 4 385 | 5 628 |
| Ceramics & glass | 1 232 | 1 136 |
| Pigments | 299 | 180 |
| Plastics | 953 | 1 318 |
| Rubber products | 200 | 64 |
| Other | 93 | 108 |
| **Total** | 7 185 | 9 864 |

Source: U.S. Bureau of Mines.
W - Withheld, confidential.

### TABLE 5. ANTIMONY PRICES, N.Y. DEALER[1]

| | 1982 | 1983 | 1984 |
|---|---|---|---|
| | | ($US/lb) | |
| January | 1.18 | 0.91 | 1.26 |
| February | 1.12 | 0.95 | 1.24 |
| March | 1.11 | 0.99 | 1.52 |
| April | 1.18 | 0.94 | 1.56 |
| May | 1.17 | 0.95 | 1.62 |
| June | 1.10 | 0.88 | 1.56 |
| July | 1.07 | 0.80 | 1.52 |
| August | 1.03 | 0.80 | 1.60 |
| September | 1.00 | 0.79 | 1.65 |
| October | 0.99 | 0.81 | 1.65 |
| November | 0.96 | 0.95 | 1.56 |
| December | 0.93 | 1.18 | 1.49 |
| | 1.07 | 0.91 | 1.51 |

Source: Metals Week.
[1] 99.5 - 99.6% metal, cif U.S. ports, 5 ton lots, duty paid.

# Arsenic

### D.G. LAW-WEST

Arsenic occurs as a minor constituent of complex ores which are mined primarily for their copper, lead, zinc, silver and gold content, although globally, copper ores are the main source of arsenic. It is collected in the form of impure arsenic trioxide in dusts and residues from the roasting of these ores. Ninety-six per cent of arsenic is consumed as arsenic trioxide and other arsenic compounds. Only about 4 per cent is consumed as metallic arsenic. In the literature, arsenic trioxide is commonly referred to as arsenic.

Prior to 1983 a limited supply and increasing demand from the agricultural and wood preservative sectors created a tight market for arsenic trioxide and consumers were placed on allocation. In 1983, demand for arsenic trioxide dropped sharply due to the reduction in consumption for agricultural usage. The resulting oversupply forced prices down nearly 20 per cent to $US 0.73 per kilogram from $US 0.88 in 1982. During 1984 arsenic prices have steadied somewhat, at about $US 0.70.

## CANADIAN DEVELOPMENTS

Canadian arsenic production is mainly obtained from the treatment of arsenious gold ores.

Campbell Red Lake Mines Limited in the Red Lake District of Ontario and Giant Yellowknife Mines Limited in the Northwest Territories, recover impure arsenic trioxide from dust and residues collected during the roasting of gold ores.

Both these operations use similar recovery technology, including electrostatic precipitation of dust, cooling of the arsenic-containing gases and collection of arsenic trioxide in a baghouse.

Giant Yellowknife, which had been storing arsenic containing residues underground, started shipping its residue production to a United States customer in 1981. The first year shipments amounted to 1 205 t, followed by 1 500 t in 1982 and 800 t in 1983. The decrease during 1983 reflected the drop in demand for arsenic in the agricultural sector. The company is currently considering plans to recover the arsenic residue from the underground storage areas. Campbell Red Lake also ships its arsenic residue to the United States.

Cominco Ltd. produced arsenic trioxide at its Con mine in the Northwest Territories until 1970, after which, gold ore being mined no longer contained arsenopyrite. The arsenic residue produced to that date had been stored in large ponds which were estimated to contain some 22 600 t of arsenic trioxide, as well as 400 kg of gold and 1 000 kg of silver. In 1981 Cominco began construction of a $13 million arsenic trioxide recovery plant which would use the stored residues as feed material and would permit the recovery of the contained gold and silver. The plant began start up operations in late 1983 and production was intermittent through 1984. Problems were encountered due to inconsistency of the feed material. The plant has a rated production capacity of 15 tpd of 99.5 per cent arsenic trioxide, most of which will be exported.

Cominco, through its Electronic Materials Division, produces high purity gallium arsenide at its Trail British Columbia plant. The company first produced gallium arsenide in 1981. Growth in demand for this product led to a plant expansion which was completed in 1983, and in 1984 further expansion of production facilities was started.

## INTERNATIONAL DEVELOPMENTS

World production of arsenic trioxide for the period 1970 to 1983 is shown in Table 1.

Two companies, Boliden Aktiebolag in Sweden and ASARCO Incorporated in the United States, are the major producers of

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metallic arsenic in the non-communist world. A few countries produce minor amounts of high purity metallic arsenic for use in the electronics industry.

Boliden is the non-communist world's largest producer of metallic arsenic with a present capacity of 1 600 t. Boliden is also of the world's largest producer of arsenic trioxide.

In the United States, ASARCO recovers arsenic trioxide from its copper smelter at Tacoma, Washington. The arsenic plant also produce metallic arsenic. In mid-1984 ASARCO announced that its copper smelter at Tacoma Washington would close by mid-1985, however, the company plans to continue operating the arsenic plant at a much reduced rate. About three quarters of the United States refinery production of arsenic trioxide comes from imported base-metal concentrates and impure arsenic trioxide and the remaining portion comes from domestic sources.

The United States is a major consumer of arsenic trioxide accounting for about 50 per cent of the western world's total consumption. In 1983 the U.S. imported some 10 200 t of arsenic trioxide for domestic consumption mainly from Sweden, Canada and Mexico.

Recently the People's Republic of China has become a large exporter of arsenic metal to the U.S. China increased its exports from 31 t in 1982 to 128 t in 1983. Sweden exported at 108 t to the U.S. in 1983.

The Philippines may soon become a major supplier of arsenic when the arsenic treatment plant, part of the Philippine Associated Smelting and Refinery Corp. (PASAR) $17 million roaster complex, is completed. The plant scheduled for start-up in early 1985 is expected to handle 5 000 tpm of high arsenic concentrate.

The El Indio Mine in Chile, started up its arsenic trioxide plant late in 1983 and after some start-up problems is producing some 300-400 t per month of 97 % arsenic trioxide.

## USES

Arsenic trioxide is the basic raw material for the production of metallic arsenic, arsenic alloys and other compounds, both organic and inorganic. The toxicity of arsenic containing compounds ranges from low to extremely high, depending on the chemical state. All must be handled with care. Environmental issues are an important factor in the recovery and use of arsenic and its compounds, and regulations on emissions to the atmosphere and on uses are being established by many countries.

Arsenic metal is used as an alloy, mainly with lead and copper, to improve strength, corrosion resistance, and other physical and chemical properties. A growing use for high-purity arsenic metal is in arsenides of gallium, indium and other metals used in electronics.

A major use of arsenic trioxide is in the preparation of compounds for use in agricultural herbicides and dessicants. The main applications are for weed control in tropical and subtropical climates, as defoliants in cotton cultivation and as weed killers in citrus orchards and rubber plantations.

Demand for arsenic compounds as wood preservatives has increased sharply in the last few years, and is expected to continue to grow, particularly if the arsenic compounds remain relatively cheap.

There are a number of minor uses for arsenic. One is in the glass industry, where arsenic trioxide is used as a decolorizing and refining agent.

ARSENIC PRICE QUOTATIONS

| | Metal 99 % As | Trioxide Mexican 99,13 % $As_2 0_3$ fob Laredo | Trioxide 95 % $As_2 O_3$ fob Tacoma |
|---|---|---|---|
| | | cents US/kg | |
| | - | 2 | 4 |
| 1970 | - | 13 | 10.4 |
| 1975 | - | 36 | no quote |
| 1980 | - | 101 | 90 |
| 1981 | 606 | 172 | 88 |
| 1982 | 540 | 130 | 88 |
| 1983 | 496 | 99 | 73 |
| 1984 | - | 93 | 70 |

Source: USBM and Metals Week

## OUTLOOK

The outlook for 1985 is somewhat uncertain. The reduced output of arsenic trioxide for the ASARCO plant could create some tightness in the market. However, this could be largely offset by increased supply from the People's Republic of China. As well, both the Philippines and Chile are expected to start up arsenic trioxide production facilities. Should the demand for arsenic trioxide from the agricultural sector again be weak, oversupply could occur and prices would be put under pressure. Demand for high purity arsenic metal is expected to continue to increase.

TABLE 1. WORLD PRODUCTION OF ARSENIC TRIOXIDE (WHITE ARSENIC) 1970-1983

| | 1970 | 1975 | 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|---|---|
| | | | (tonne s) | | | |
| U.S.S.R. | 7 149 | 7 348 | 7 711 | 7 700 | 7 900 | 8 000 |
| Mexico | 9 140 | 6 121 | 6 532 | 6 500 | 4 800 | 5 000 |
| France | 10 193 | 8 165 | 5 262 | 5 300 | 5 200 | 5 000 |
| Sweden | 16 400 | 15 967 | 4 082 | 4 100 | 4 000 | 4 000 |
| Peru | 772 | 1 325 | 2 540 | 2 500 | 2 200 | 2 200 |
| Namibia | 4 062 | 6 663 | 1 996 | 2 000 | 1 900 | 2 000 |
| Other countries[1][e] | 16 223 | 14 340 | 6 262 | 10 600 | 9 000 | 8 000 |
| Total | 63 939 | 59 929 | 34 385 | 38 700 | 45 293 | 39 883 |

Sources: U.S. Bureau of Mines, Yearbook 1970-1980; Mineral Commodity Summary 1982, 1983, 1984.

[1] Includes the United States but not the Peoples' Republic of China; United States production figures are withheld by the United States to avoid disclosing individual company data; estimates for the years 1970-1975 from Roskill Information Services Ltd.; for the years 1976-1981 estimated by Nonferrous Section, Mineral Supply Branch, Energy, Mines and Resources Canada.

[e] Estimated.

# Asbestos

G.O. VAGT

Shipments of asbestos (chrysotile) in 1983-84 remained weak as a result of worldwide recessionary conditions particularly in the construction industry, foreign exchange shortages in the developing countries, uncertainties regarding future environmental regulations, and adverse publicity associated with past exposure to asbestos dust in the workplace. Total shipments in 1983 were 857 504 t valued at $391.3 million and in 1984 were 836 000 t valued at $413.0 million, according to preliminary figures.

The entire asbestos industry is undergoing the most critical period in its history. Since 1981, greatly reduced mine production, coupled with high inventories of more than 150 000 t, have resulted in shortened work periods, layoffs, prolonged shutdowns, and the closure of one operation. Employment in the mining sector of this industry has been depressed to under 4,000 from about 8,000 in 1979. Exports, generally accounting for about 95 per cent of production, amounted to 604 000 t valued at $378 million during the first 9 months of 1984, compared to 551 000 t valued at $327 million during the same period in 1983.

Canada recognizes that asbestos dust in the workplace is potentially hazardous. However, it takes the position that via enforcement of appropriate regulations to rigorously control exposure, the use of chrysotile in most activities from mining through manufacturing does not pose undue risk to workers or the public. This position is generally characteristic of the mainstream international approach except in the United States where the Environmental Protection Agency plans to propose regulations to ban key asbestos-containing products and to ultimately phase out all remaining asbestos uses.

## CANADIAN DEVELOPMENTS

Companies in the industry are operating at about 55-60 per cent of capacity overall, with individual operations ranging from 35-40 per cent to 80 per cent. Quebec accounts for 85-90 per cent of total output.

Asbestos Corporation Limited (ACL) discontinued mining in May, 1983 at its seasonal operation in Ungava. During the past 10 years approximately 2 million t of concentrate (about 700 000 t of asbestos) were shipped from Asbestos Hill to Nordenham, Federal Republic of Germany, for final milling. The closure will reportedly help preserve jobs at the company's operations in Thetford Mines-Black Lake. Most of the assets in the Federal Republic of Germany were sold in mid-1984. ACL and Bell Asbestos Mines held discussions initially in mid-1984 to discuss consolidating operations. Losses at ACL amounted to $68 million from 1981 to the first six months of 1984 inclusive.

Johns-Manville Canada Inc. sold its Jeffrey operation to a group of private investors. The $117 million sale, approved in September 1983, was part of a reorganization plan submitted by the parent Manville Corporation in 1982 when it filed for protection under Chapter XI of the U.S. Bankruptcy Code. The former parent is now essentially removed from the asbestos business.

A feasibility study for Brinco Mining Limited concluded that an extension of the present Mt. McDame orebody is mineable by underground methods. A commitment to proceed with development would be required by mid-1985 if development is to be fully completed when the open-pit reserves are exhausted by about 1991.

Baie Verte Mines Inc., a new company owned by Transpacific Asbestos Inc., of Toronto, has been successfully marketing asbestos mainly in Pacific Rim countries. This operation, formerly Advocate Mines Limited, was rejuvenated following expropriation by the Government of Newfoundland and the availability of government loans and loan guarantees. Shipping and cash-flow were cited recently as problems leading

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to a decision in late-1984 to shut down operations for one month extending into 1985.

The Société nationale de l'amiante (SNA) continued its research and development on new products and processes involving chrysotile. Substantial efforts have been directed toward modifying the surface characteristics of asbestos, or other materials, to attenuate physiological response. Present work involves treatment of the fibres with phosphorous oxychloride ($POCl_3$) to fix magnesium phosphate having low solubility and high thermal stability. The resulting product is called chrysophosphate.

The Asbestos Institute became operational in mid-1984. This industry-managed asbestos research institute, financed jointly by the Canadian asbestos industry and the Governments of Canada and Quebec, will be responsible for product and health research, market development and the dissemination of information on the safe uses of asbestos. Thus, the Institute, with operating funds up to a total of $18.75 million over the next five years, takes over and expands the functions of the Canadian Asbestos Information Centre, the Institute for Research and Development (IRDA) and the Institute for Occupational and Environmental Health (IOEH).

## HEALTH AND REGULATIONS

The Royal Commission on Matters of Health and Safety Arising from the Use of Asbestos in Ontario (ORCA report) issued its comprehensive three-volume report in May 1984. Some important highlights of the report are:

1) Distinction between types of fibres for regulatory purposes, prohibition being recommended for crocidolite and amosite, and chrysotile being subjected to a level of 1.0 fibres/cm$^3$, which is in fact already in effect in Ontario.

2) There should be a distinction between types of processes when considering regulations for manufacturing plants.

3) There is no evidence of significant health risk to the general public from exposure to asbestos in the ambient air and in buildings. For workers and maintenance people in the immediate vicinity of loose asbestos there is a potential hazard.

4) There is no health risk from ingestion. Concern about asbestos in drinking water, beverages and food is not justified. The Commission recommends lifting the ban on the use of asbestos filters in the production of beer, wine and liquor.

It was decided in 1983 by the Ontario Ministry of Labour to postpone finalization of its proposed asbestos regulation for the construction industry until the ORCA report was reviewed. The present general occupational regulation, following the British standard, establishes different permissible exposure limits according to fibre type. These limits are, 1.0 f/cm$^3$ for chrysotile, 0.5 f/cm$^3$ for amosite and 0.2 f/cm$^3$ for crocidolite as measured over a 40-hour time-weighted period by the membrane filter method.

Federal emission regulations pursuant to the Clean Air Act as defined by Environment Canada require that the concentration of asbestos fibres contained in emissions to the ambient air at a mine or mill from crushing, drying or milling operations, or from dry rock storage, shall not exceed 2 f/cm$^3$.

## WORLD DEVELOPMENTS AND INTERNATIONAL REGULATIONS

Based on an estimated 1983 world production of 4.2 million t of fibre, major producers and their approximate percentage share of production are: U.S.S.R., 54; Canada, 20; Republic of South Africa, 5; and Zimbabwe, 4.5. Canadian asbestos fibre exports account for approximately 65 per cent of total world exports. Expansions to production facilities in Russia are under way, reportedly to serve the needs of industrial and residential construction.

The Occupational Safety and Health Administration (OSHA) issued an Emergency Temporary Standard (ETS) in late 1983 without prior public hearings. This rarely used approach called for an immediate reduction in the permissable level of worker exposure from 2.0 f/cm$^3$ to 0.5 f/cm$^3$. Following a court challenge, a unanimous three-judge panel ruled that OSHA did not invoke its ETS powers properly and that the record, as a whole, does not indicate that the risk the ETS sought to eliminate was "grave", as OSHA itself has defined it. OSHA's normal rule-making route then proceeded throughout 1984.

In most countries there has been increasing acceptance for the "controlled use" principle as an approach to asbestos regulation. However, the U.S. Environmental Protection Agency (EPA) announced in late-1983 that it planned to propose a ban in 1984 on certain important asbestos product categories and a "staged production cap" on the manufacturing of the remaining products. The timing was not realized and efforts were continuing at the end of 1984.

There is also much apprehension over the removal of asbestos in American schools. Allotted funds to the end of 1984 for asbestos removal totalled $50 million, however, there is lack of agreement on cost sharing by the levels of government involved. EPA has not yet formulated acceptable procedures for removal, and further, the entire issue is controversial because several authorities have stated that there is no evidence of cancer where there is a low level of exposure in buildings.

Asbestos-related product liability lawsuits alleging past damages continued and now number about 24,000 cases. These are unique to the United States. The American Bar Association in 1983 urged Congress to find a way to handle the suits, stipulating that the problem should not be left any longer to state and federal courts applying the varied laws of 50 states.

In the United Kingdom, the governments Health and Safety Commission recommended in mid-1983 strict new control limits for asbestos in the workplace. New limits, particularly for chrysotile, came as a surprise because the 1.0 f/cm$^3$ figure was just established early in the year. Effective August 1 1984, limits would be; crocidolite, 0.2 f/cm$^3$; amosite, 0.2 f/cm$^3$ and chrysotile, 0.5 f/cm$^3$. Similarly, beginning June 1, 1984, the import and use of crocidolite and amosite, and products containing them, would formally be banned.

The Council of the European Communities (CEC) approved in 1983 directives on asbestos regulations regarding marketing and use (DG III) and protection in the workplace (DG V). The control limit for exposure to asbestos fibre (DG V), other than crocidolite, over an eight-hour sampling period will be 1.0 f/cm$^3$. Member states are to adopt laws necessary to comply with the workplace directive before Jan. 1, 1987. In the case of asbestos-mining activities the compliance date is Jan. 1, 1990. For crocidolite, the limit value will be 0.5 f/cm3. The marketing and use of products containing chrysotile is permitted with proper labelling, but prohibitions on the marketing and use of many crocidolite-containing products will apply to products manufactured after Jan. 1, 1986. However, member states may exclude from the prohibition certain products, including fibres for asbestos cement pipe, acid and heat resistant seals, packings and gaskets, and torque converters.

In the Federal Republic of Germany, manufacturers in the fibre-cement industry continued to reduce voluntarily the asbestos content in asbestos-cement products. Also, substitutes for many products, including friction materials, are being promoted aggressively. Sprayed-on applications have been banned since 1979.

In Denmark, the Danish Labor Inspectorate proposed new threshhold limit values that are specific to natural mineral fibres as well as to asbestos. Limits, effective in January 1985 are as follows: for asbestos fibres, excluding crocidolite which is banned, 0.5 f/cm$^3$, for natural mineral fibres including wollastonite, attapulgite and zeolites, 0.5 f/cm$^3$; and for synthetic mineral fibres including glass, mineral and slag wool, 1.0 f/cm$^3$.

A draft code of practice on the safe use of asbestos was approved in October 1983 at an International Labor Office (ILO) meeting. The code, drawn up by experts selected by governments, workers and employers throughout the world, advocates the continued use of asbestos in line with the application of standards and controls that minimize the risk of exposure to asbestos dust in the workplace. The subject code and the safe use of asbestos have been included in the agenda for the 1985 ILO conference and the final instruments are to be presented for ratification at the 1986 Conference.

The World Health Organization largely completed a criteria document on asbestos and man-made mineral fibres in 1984. These types of documents are highly regarded for their objectivity and are particularly relevant to many countries in the process of establishing regulations for fibrous minerals.

The Air Management Policy Group of the Organization for Economic Cooperation and Development (OECD) held meetings to prepare a policy document on asbestos in the ambient air. This document will be reviewed for release in 1985.

Adverse publicity associated with asbestos continues in Australia. According to a recent budget speech, funding has been provided to establish the extent of asbestos usage in Commonwealth buildings.

Woodsreef Mines Limited developed a method of recovering fibre from both ore and mill tailings at its Australian mine using a wet-milling process. The company planned to restart commercial operations in 1985 with a new wet mill. Production using the dry-process ceased in January, 1983.

An industry/government asbestos mission visited Saudi Arabia, Kuwait, United Arab Emirates (Dubai) and Egypt in May, 1984. A Chinese Asbestos Study Group from the Ministry of Geology and Mineral Resources, Beijing, PRC visited the mining region in Quebec during October, 1984.

## PRICES AND CONSUMPTION

The average unit prices received for asbestos have not increased since 1981; these in fact have declined in real terms. The general economic recession affecting the construction and automotive sectors has been a major factor depressing demand and increasing competition for available markets. About 70 per cent of production is construction-product related (asbestos/fibre cement, papers, felts, flooring and others), with friction materials accounting for about 10 per cent.

Price competition has led to much discounting because supply has far exceeded demand. Also, in addition to the traditional competitors, Brazil, Greece, and Colombia have recently entered world markets.

### Alternate Fibres and Materials

The controversial health issue and stricter regulations on use have resulted in rapid growth in the use of alternate fibres and products. These have made significant inroads even though the cost/performance ratio may be much in favor of asbestos.

In April, 1984, at a two-day symposium on asbestos replacements held in Manchester, England, it was concluded that asbestos remains the most technical- and cost-efficient material in the face of proposed replacements. However, given the sheer volume of research to develop adequate substitutes in all product areas, including brake linings, flooring materials, papers and felts, all markets in fact, are genuinely threatened.

## OUTLOOK

The general economic recovery may not improve prospects in the asbestos industry given continued weakness in foreign demand, uncertain regulatory trends and the utilization of substitutes where possible. Clearly, future demand will largely depend on the industry's success in stemming the negative public perception of asbestos in the industrialized countries and the emerging concerns in developing countries.

Given the firm commitments in some countries to minimize the use of asbestos, Canadian mine production during this decade may continue at today's depressed level, or even decrease further to around 700 000 tpy. With current available production capacity at about 1.2 million tpy, the oversupply situation, along with expected continuing weak prices, indicates that additional rationalization may take place in the Canadian industry. Clearly, a major challenge will be to keep production costs down allowing companies to sell competitively, particularly in developing countries where there is growth potential. Although there are established requirements for asbestos-cement products in construction and irrigation projects in these countries, foreign exchange and debt problems will probably continue to be major obstacles hindering potential growth.

Industry considers that there is a pressing need to develop new products and applications to offset the effects of phasing out of some mature products and of inroads made by some viable alternatives. Thus, coordinated research and development efforts should strive to improve the performance, safety and reliability of existing products and technologies. An important base on which to build is the reputation of Canadian asbestos fibre world wide.

## TABLE 1. CANADA, ASBESTOS PRODUCTION AND TRADE, 1982-84

| | 1982 | | 1983P | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Production (shipments)**[1] | | | | | | |
| By type | | | | | | |
| Crude, groups 1, 2 and other milled | - | - | - | - | | |
| Group 3, spinning | 13 007 | 15,640 | 13 599 | 17,252 | .. | .. |
| Group 4, shingle | 217 840 | 172,550 | 271 374 | 199,019 | .. | .. |
| Group 5, paper | 163 707 | 89,659 | 163 980 | 89,584 | .. | .. |
| Group 6, stucco | 149 982 | 46,197 | 157 958 | 49,090 | .. | .. |
| Group 7, refuse | 289 713 | 40,749 | 250 593 | 36,348 | .. | .. |
| Group 8, sand | - | - | - | - | .. | .. |
| Total | 834 249 | 364,795 | 857 504 | 391,293 | 836 000 | 412,978 |
| By province | | | | | | |
| Quebec | 745 475 | 298,143 | 744 486 | 321,212 | 695 000 | 301,118 |
| British Columbia | 76 084 | 57,032 | 81 653 | 53,396 | 94 000 | 88,360 |
| Newfoundland | 12 690 | 9,620 | 31 365 | 16,686 | 47 000 | 23,500 |
| Total | 834 249 | 364,795 | 857 504 | 391,294 | 836 000 | 412,978 |
| **Exports** | | | | | | |
| Crude | | | | | (Jan. - Sept.) | |
| Japan | 494 | 148 | 772 | 267 | 1 093 | 351 |
| United States | 61 | 9 | 96 | 14 | 144 | 42 |
| United Kingdom | - | - | 34 | 8 | 35 | 6 |
| Singapore | - | - | 18 | 19 | - | - |
| Argentina | - | - | 11 | 14 | - | - |
| Belgium-Luxembourg | - | - | - | - | 17 | 4 |
| West Germany | - | - | - | - | 17 | 5 |
| Total | 555 | 157 | 931 | 323 | 1 306 | 408 |
| Milled fibre (groups 3, 4 and 5) | | | | | | |
| West Germany | 68 853 | 50,541 | 23 243 | 23,865 | 18 922 | 18,563 |
| Japan | 36 214 | 24,728 | 30 099 | 23,511 | 23 577 | 17,887 |
| United States | 34 850 | 30,186 | 33 150 | 30,254 | 39 584 | 37,115 |
| France | 30 497 | 25,415 | 29 525 | 27,588 | 17 761 | 15,236 |
| India | 28 208 | 24,099 | 27 955 | 23,324 | 18 860 | 17,160 |
| United Kingdom | 25 056 | 23,632 | 20 916 | 21,266 | 15 625 | 16,044 |
| Mexico | 20 413 | 16,315 | 12 616 | 11,526 | 13 890 | 13,300 |
| Italy | 16 529 | 16,059 | 14 122 | 14,325 | 13 989 | 14,471 |
| Australia | 14 768 | 14,211 | 8 473 | 8,740 | 8 442 | 9,070 |
| Malaysia | 11 302 | 9,935 | 13 847 | 11,649 | 6 218 | 5,812 |
| Thailand | 10 014 | 7,813 | 14 527 | 11,796 | 13 087 | 9,716 |
| Spain | 10 512 | 10,496 | 2 854 | 2,632 | 1 870 | 1,767 |
| Belgium-Luxembourg | 7 871 | 7,292 | 9 329 | 8,690 | 6 626 | 6,448 |
| Austria | 6 808 | 5,470 | 12 228 | 9,772 | 8 325 | 7,544 |
| Other countries | 132 545 | 111,263 | 131 184 | 121,553 | 115 087 | 104,864 |
| Total | 454 440 | 377,455 | 384 068 | 350,491 | 321 863 | 294,997 |
| Shorts (groups 6, 7, 8 and 9) | | | | | | |
| United States | 191 112 | 38,588 | 149 451 | 33,279 | 108 507 | 24,977 |
| Japan | 70 427 | 19,957 | 59 531 | 18,114 | 47 330 | 14,577 |
| United Kingdom | 18 050 | 4,420 | 12 351 | 3,606 | 9 001 | 2,703 |
| West Germany | 17 238 | 4,915 | 17 630 | 5,736 | 11 795 | 3,975 |
| France | 13 467 | 2,614 | 8 546 | 2,129 | 4 361 | 1,159 |
| Mexico | 12 741 | 3,555 | 6 307 | 1,525 | 6 546 | 1,628 |
| India | 11 059 | 3,429 | 15 719 | 5,549 | 6 359 | 2,194 |
| Thailand | 7 610 | 2,603 | 9 096 | 3,474 | 11 938 | 5,425 |
| Taiwan | 7 118 | 2,733 | 11 739 | 4,693 | 13 123 | 5,667 |
| South Korea | 5 857 | 1,390 | 12 539 | 3,416 | 9 872 | 2,344 |
| Belgium-Luxembourg | 5 773 | 1,972 | 5 449 | 2,123 | 6 161 | 2,619 |
| Venezuela | 4 347 | 1,102 | 2 506 | 548 | 2 715 | 546 |
| Argentina | 4 156 | 1,163 | 4 185 | 1,474 | 5 743 | 1,688 |
| Nigeria | 2 595 | 766 | 6 094 | 1,934 | 1 382 | 391 |
| Switzerland | 779 | 195 | 997 | 262 | 120 | 25 |
| Other countries | 53 372 | 15,618 | 46 773 | 16,226 | 35 898 | 12,556 |
| Total | 425 701 | 105,020 | 368 913 | 104,088 | 280 848 | 82,474 |
| Grand total crude, milled fibres and shorts | 880 696 | 482,632 | 753 912 | 454,902 | 604 017 | 377,879 |

TABLE 1. (cont'd)

| | 1982 | | 1983P | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000)<br>(Jan. - Sept.) |
| Manufactured products | | | | | | |
| Asbestos cloth, dryer felts, sheets | | | | | | |
| United States | | 1,847 | | 1,879 | | 1,086 |
| United Kingdom | | 505 | | 217 | | 429 |
| Japan | | - | | 93 | | 2 |
| Other countries | | 501 | | 1,085 | | 1,621 |
| Total | .. | 2,853 | .. | 3,274 | | 2,138 |
| Brake linings and clutch facings | | | | | | |
| United States | | 9,691 | | 8,069 | | 6,524 |
| Australia | | 160 | | 112 | | 87 |
| Hong Kong | | 152 | | 108 | | 42 |
| West Germany | | 128 | | 72 | | 46 |
| Ecuador | | 66 | | - | | - |
| France | | 13 | | 21 | | - |
| Other countries | | 160 | | 99 | | 85 |
| Total | .. | 10,370 | .. | 8,481 | | 6,784 |
| Asbestos and asbestos cement building materials | | | | | | |
| United States | | 12,805 | | 10,416 | | 6,150 |
| United Kingdom | | 816 | | 467 | | 363 |
| Australia | | 636 | | 204 | | 139 |
| Singapore | | 370 | | 66 | | 105 |
| Venezuela | | 359 | | - | | 165 |
| Egyptian A.R. | | 285 | | 100 | | 23 |
| Indonesia | | 113 | | 171 | | 31 |
| South Africa | | 81 | | 10 | | 43 |
| Malaysia | | 64 | | 364 | | 48 |
| Other countries | | 1,959 | | 791 | | 1,462 |
| Total | .. | 17,488 | .. | 12,589 | | 8,529 |
| Asbestos basic products, nes | | | | | | |
| United States | | 6,646 | | 3,731 | | 2,303 |
| West Germany | | 158 | | 117 | | 539 |
| Australia | | 37 | | 119 | | - |
| Mexico | | 3 | | 18 | | 134 |
| Other countries | | 440 | | 223 | | 362 |
| Total | .. | 7,284 | .. | 4,208 | | 3,338 |
| Total exports, asbestos manufactured | .. | 37,995 | .. | 28,552 | | |
| **Imports** | | | | | | |
| Asbestos, unmanufactured | 573 | 687 | 454 | 483 | 291 | 415 |
| Asbestos, manufactured | | | | | | |
| Cloth, dryer felts, sheets, woven or felted | | 1,306 | | 898 | | 819 |
| Packing | | 2,803 | | 2,803 | | 1,744 |
| Brake linings | | 9,740 | | 12,020 | | 16,181 |
| Clutch facings | | 1,224 | | 1,348 | | 1,460 |
| Asbestos-cement shingles and siding | | 56 | | 55 | | 77 |
| Asbestos-cement board and sheets | | 439 | | 670 | | 398 |
| Asbestos building materials, nes | | 1,856 | | 1,025 | | 1,120 |
| Asbestos basic products, nes | | 4,846 | | 1,590 | | 823 |
| Total asbestos, manufactured | .. | 22,270 | .. | 20,409 | | 22,622 |
| Total asbestos, unmanufactured and manufactured | .. | 22,957 | .. | 20,892 | | 23,037 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Value of containers not included.
P Preliminary; - Nil; nes Not elsewhere specified; .. Not available.

TABLE 2. CANADIAN ASBESTOS PRODUCERS, 1984

| Producers | Mine Location | Mill Capacity ore/day (tonnes) | Mill Capacity fibre/year (tonnes) | Remarks |
|---|---|---|---|---|
| Baie Verte Mines Inc. | Baie Verte, Nfld. | 6 600 | 80 000 | Open-pit. |
| Carey Canada Inc. | East Broughton, Que. | 6 800 | 210 000 | Open-pit. Mainly produces groups 6 and 7. |
| Asbestos Corporation Limited | | | | Purchased in 1982 by Société nationale de l'amiante (SNA) (Quebec Crown corporation). |
| Asbestos Hill mine | Putuniq, Que. | 5 400 | | Mining ceased indefinitely in 1983. |
| British Canadian mine | Black Lake, Que. | 12 000 | | Open-pit, two milling plants. |
| King-Beaver mine | Thetford Mines, Que. | 7 000 | 210 000 | Underground and open-pit. |
| Normandie mine | Black Lake, Que. | | | Reserves exhausted. Mill processes K-B open-pit ore. |
| Bell Asbestos Mines, Ltd. | Thetford Mines, Que. | 2 700 | 75 000 | Underground. Purchased in 1980 by SNA (Quebec Crown corporation). |
| Lake Asbestos of Quebec, Ltd. | Black Lake, Que. | 9 000 | 235 000 | Open-pit. |
| National Mines Division | Thetford Mines, Que. | 4 000 | | Open-pit. |
| JM Asbestos Inc. | | | | |
| Jeffrey mine | Asbestos, Que. | 15 000 | 300 000 | Open-pit (effective capacity reduced by one-half). |
| Brinco Mining Limited | | | | |
| Cassiar mine | Cassiar, B.C. | 5 000 | 100 000+ | Open-pit. |

## TABLE 3. CANADA, ASBESTOS PRODUCTION AND EXPORTS, 1978-84

| | Crude | Milled | Shorts | Total |
|---|---|---|---|---|
| | (tonnes) | | | |
| **Production**[1] | | | | |
| 1978 | 1 | 673 910 | 747 897 | 1 421 808 |
| 1979 | 4 | 725 649 | 767 066 | 1 492 719 |
| 1980 | - | 690 493 | 632 560 | 1 323 053 |
| 1981 | 10 | 567 288 | 554 547 | 1 121 845 |
| 1982 | - | 394 554 | 439 695 | 834 249 |
| 1983P | - | 448 953 | 408 551 | 857 504 |
| 1984P | .. | .. | .. | 836 000 |
| **Exports** | | | | |
| 1978 | 1 | 689 690 | 708 392 | 1 398 083 |
| 1979 | 20 | 719 075 | 741 947 | 1 461 042 |
| 1980 | - | 653 358 | 564 379 | 1 217 737 |
| 1981 | 10 | 519 777 | 542 402 | 1 062 189 |
| 1982 | 555 | 454 440 | 425 701 | 880 696 |
| 1983P | 931 | 384 068 | 368 913 | 753 912 |
| 1984P(Jan.-Sept.) | 1 306 | 321 863 | 280 848 | 604 017 |

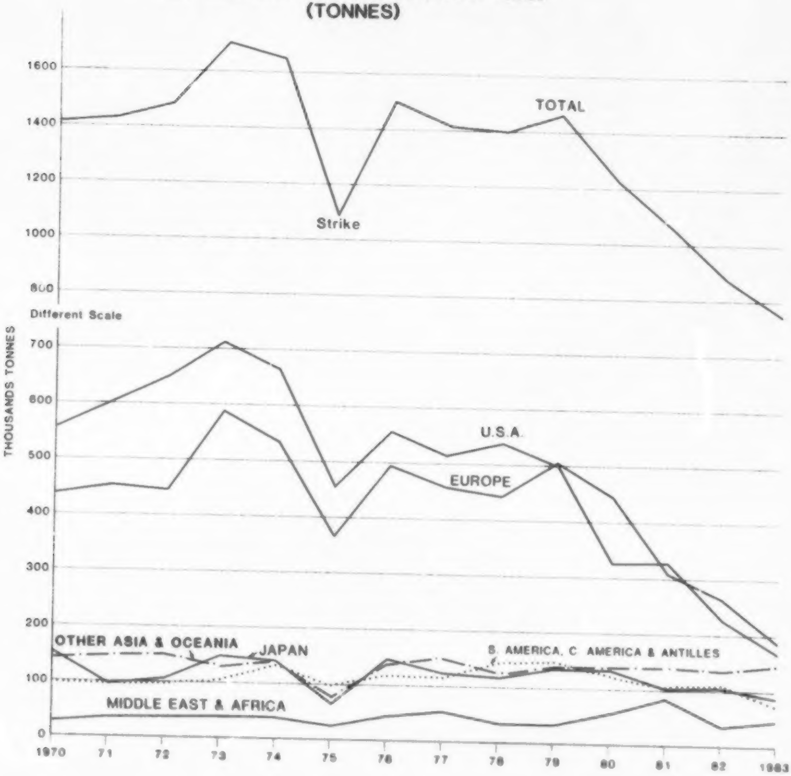
Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Producers' shipments.
P Preliminary; .. Not available; - Nil.

## TABLE 4. WORLD ASBESTOS PRODUCTION, 1983

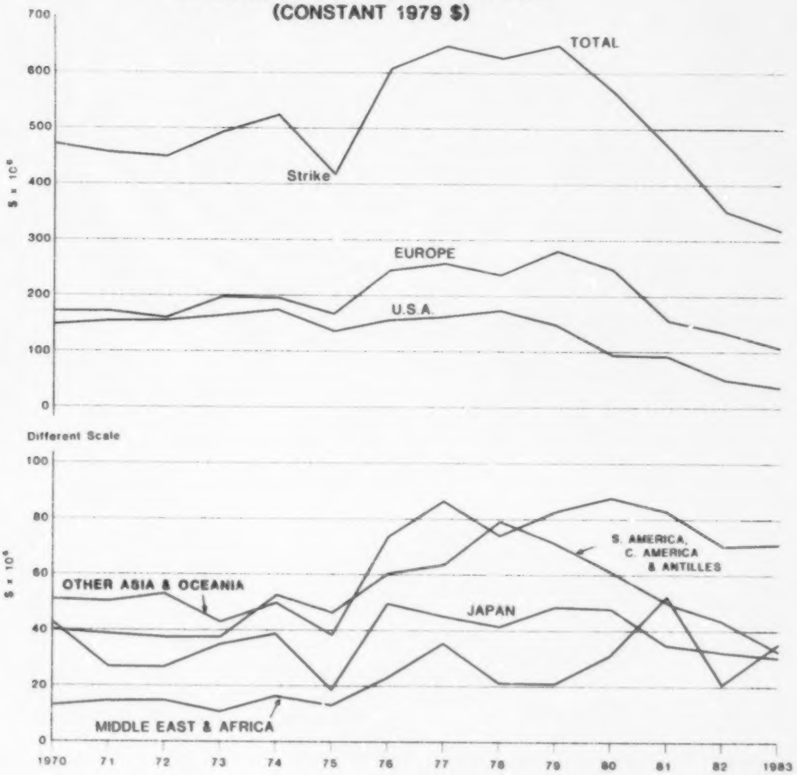
| Country | | tonnes[e] |
|---|---|---|
| U.S.S.R.[e] | | 2 250 000 |
| Canada | | 857 504 |
| Rep. of South Africa | | 220 000 |
| Zimbabwe | | 190 000 |
| Brazil | | 135 000 |
| Italy | | 120 000 |
| China | | 110 000 |
| Greece | | 100 000 |
| United States | | 69 906[1] |
| India | | 25 000 |
| Australia | | 20 000 |
| Cyprus | | 18 000 |
| Korea | | 15 000 |
| Turkey | | 4 000 |
| Swaziland | | 31 275[1] |
| Mozambique | | 800 |
| Yugoslavia | ) | 10 500 |
| Japan | ) | 4 000 |
| Taiwan | ) | 2 500 |
| Argentina | ) | 1 350 |
| Bulgaria | | 600 |
| Egypt | ) | 325 |
| | | 4 185 760 |

Sources: United States Bureau of Mines and Energy, Mines and Resources Canada.
[1] Reported figure.
[e] Estimated.

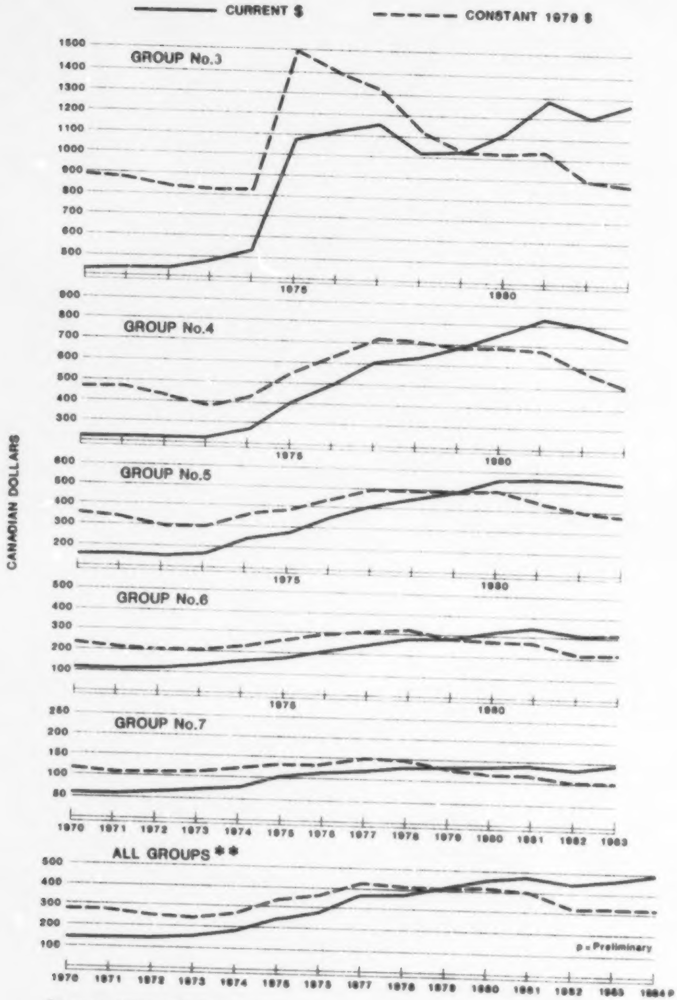
CANADIAN EXPORTS OF ASBESTOS (ALL GROUPS)
BY COUNTRY OR REGION (1970–1983)
(TONNES)



CANADIAN EXPORTS OF ASBESTOS (ALL GROUPS)
BY COUNTRY OR REGION (1970-1983)
(CONSTANT 1979 $)



# ASBESTOS - CALCULATED AVERAGE UNIT PRICES (BY TONNE SHIPPED) *



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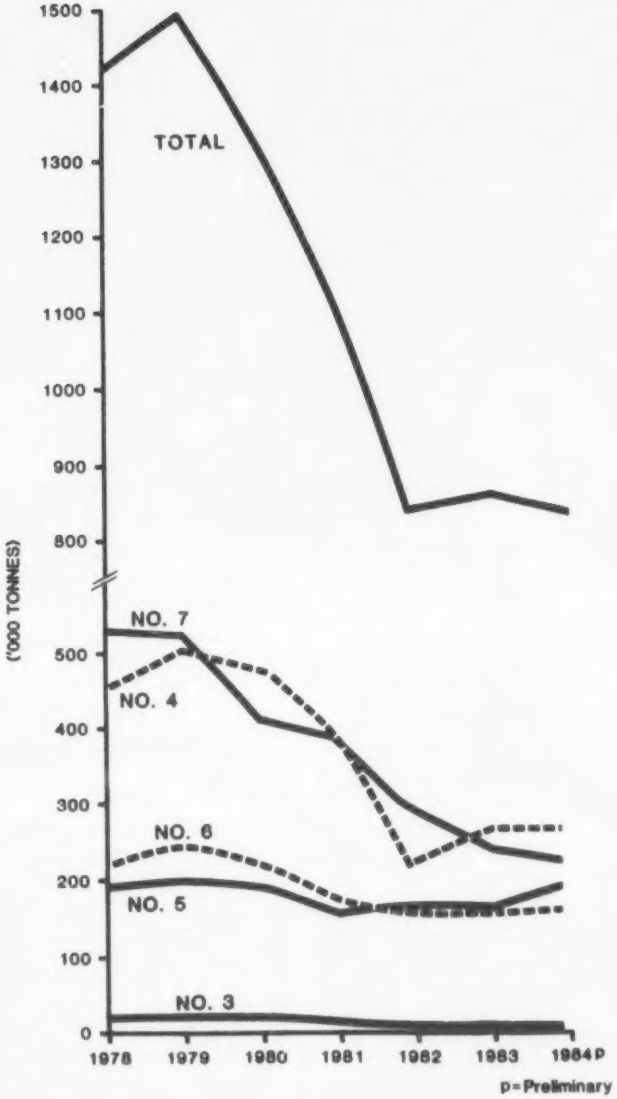
* PRICES ($CDN AS REPORTED BY COMPANIES) ARE FOB MINE AND DO NOT INCLUDE CONTAINERS, SALES TAXES, EXCISE DUTIES AND EXCISE TAXES, OUTWARD TRANSPORTATION CHARGES AND SALES DISCOUNTS OR ALLOWANCES.

** AVERAGE PRICES OF ALL GROUPS GENERALLY INCLUDES SMALL QUANTITIES OF GROUPS No. 1, 2, AND 8.

## CANADIAN ASBESTOS SHIPMENTS
## 1978-1984



# Barite and Celestite

G.O. VAGT

## SUMMARY

Canadian shipments of barite in 1984 amounted to 46 884 t valued at an estimated $7.45 million. This compares to 45 465 t valued at $4.87 million shipped in 1983. The industry generally experienced moderate recovery since 1982 when shipments dropped substantially following a decline in oil- and gas-well drilling activity, particularly in western Canada. Imports of barium carbonate in 1983, one of the most important barium chemicals derived from barite, amounted to 3 699 t valued at $1,253,000. In the first nine months of 1984 imports were 2 857 t valued at $930,000.

Barite ($BaSO_4$) is a valuable industrial mineral because of its high specific gravity (4.5), low abrasiveness, chemical stability and lack of magnetic and toxic effects. Its dominant use is as a weighting agent in the oil- and gas-well drilling muds required to counteract high pressures confined by the substrata.

This mineral is found in many countries of the world and is the raw material from which nearly all other barium compounds are derived. The major world producers of barite, excluding the U.S.S.R. and most centrally planned economies are the United States, China, Morocco, India, Thailand, Mexico and Peru. Recently, China has become very important in world trade and is the leading exporter of barite to the United States.

## CANADIAN DEVELOPMENTS

Barite was produced during 1983-84 from operations in British Columbia, Ontario and Nova Scotia. Production in Newfoundland was intermittent.

Mountain Minerals Co. Ltd., in eastern British Columbia, reactivated its Parson Mine in 1983 following extensive development of underground vein deposits in 1980-81. The Brisco Mine and Mineral King mine, past producers with limited reserves, did not operate. All of the crude barite from the Parson mine is shipped to the company's grinding plant at Lethbridge, Alberta. Magcobar Minerals Division of Dresser Canada Inc., started production in 1984 from the Fireside deposit near kilometre 588 of the Alaska Highway. In 1983, Baroid of Canada, Ltd. processed small quantities of old tailings at the Silver Giant property near Spillimacheen. At intervals, Baroid also processes crude barite at its grinding plant in Onoway, Alberta.

Extender Minerals of Canada Limited mines barite near Matachewan, Ontario. Production is from a vein deposit by open-pit methods and the high-quality dry-ground product is used for filler and extender pigments in paints and plastics.

ASARCO Inc. and Abitibi Price Inc., beginning in 1982, recovered barite on a seasonal basis from old tailings at the Buchans mine, in Newfoundland. There was no production in 1983 and limited output in 1984 as sales contracts were irregular. Reserves of barite in the tailings are approximately 450 000 t averaging about 35 per cent. Also in Newfoundland, at Collier Point, on the Avalon Peninsula, mining by several companies has been intermittent since 1980. In 1983 about 2 000 t were produced and in 1984 Eagle Resources produced several thousand t according to the Department of Mines and Energy.

In Nova Scotia Nystone Chemicals Ltd. mined pharmaceutical-grade barite from its deposit 2 miles northeast of Brookfield. Some drilling-grade barite was produced for the first time in 1984. Novex Mining and

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Exploration started production at its Lake Uist mine, in Richmond County. Ore is concentrated by flotation at Enon, Cape Breton County and is used for well drilling. At Upper Bass River in Colchester County the Magcobar Division of Dresser Canada Inc. recovered barite from a small, run-of-mine operation. Ore was shipped to Walton, Hants County for final grinding.

A large, unique occurrence of barite-gold mineralization was found in 1983 to be associated with the Hemlo gold deposits 250 km east of Thunder Bay, Ontario. The barite is stratabound extending for several kilometres along strike in an Archean metavolcanic rock belt. At the Golden Giant Deposit No. 1, a Noranda Mines - Golden Giant joint venture, barite content ranges from 5 to 40 per cent. Indicated reserves of barite may be 2 million t assuming 20 million t of gold ore containing 10 per cent barite. However, no plans have been announced to recover the barite.

## CONSUMPTION

In 1982 consumption of barite in Canada was 25 477 t based on estimates. About 80 per cent was used for well drilling. The balance of Canada's barite consumption was in the manufacture of paint and varnish, rubber, chemicals, brake linings and other products. Growth in demand is expected in the automotive primer paint markets and also in new plastic applications in flooring and firewall parts.

## WORLD DEVELOPMENTS

World production of barite in 1983 was 5 791 million t, according to the United States Bureau of Mines. The abrupt decrease in output since 1981-82 reflected reduced well drilling as a result of the recession and a persistent oil glut.

The United States, previously by far the world's largest producer of barite, mainly from Nevada, produced an estimated 0.68 million t in 1983. Production in China was an estimated 1.0 million t in 1983 and surpassed the United States for the first time in 1983. Imports of barite to the United States during 1983 and 1984 were 1.2 million t and 1.6 million t respectively. Beginning in 1982, U.S. imports have been higher than domestic production and in 1983 net import reliance as a per cent of apparent consumption was 66 per cent. Substantial increases in shipments of crude ore from China to Gulf Coast ports mainly accounted for this shift. Lower oil- and gas-well drilling activity continued in 1984 resulting in further cutbacks in mine production and excess capacity at grinding plants. In Nevada more than 20 companies operated in 1980 whereas today only about six major operators remain. For the most part, these are fully integrated into the oil-well servicing industry.

The downward trend in drill-rig utilization in virtually all countries resulted in cutbacks of production or complete closures of numerous mining operations during 1983-84. An exception was Strontian Minerals, a member of the Minworth group of companies. It started producing drilling-grade barite from its barite, lead-zinc-silver mine and processing plant near Strontian in Scotland. Plant production capacity totals 50 000 tpy and the barite will serve the North Sea drilling market. A range of grades for non-drilling-uses is expected to be produced in the future when the operation changes from quarry to underground methods.

## PRICES

Substantial overcapacity and low ocean-freight rates in the 1983-84 period resulted in some published prices falling by as much as 25 per cent for unground material priced in the range of $US 50 a t. Low-cost crude barite exported from China to the United States played an important role in depressing western world prices. Prices in the range of $US 200-400 for barite used in smaller quantities in chemical and filler/extender markets remained about the same.

## USES

Principal specifications for barite used in well-drilling usually require a minimum specific gravity of about 4.2, a particle size of 90-95 per cent minus 325 mesh, and a maximum of 250 ppm soluble alkaline earths, as calcium.

Barite is used in paint as a special filler or "extender pigment". This is a vital constituent that provides bulk, improves consistency of texture, surface characteristics and application properties, and controls prime pigment settling and viscosity. Specifications for barite used in the paint industry call for 95 per cent $BaSO_4$, particle size at least minus 200 mesh, and a high degree of whiteness or light reflectance. Final "wet milled" and "floated" products result in smooth micro-crystalline surfaces that prevent agglomeration, thus allowing easy dispersal in water as well as in oil-soluble binders. When barite is used in highly pigmented distemper or latex paints, a degree of light scattering is attributed to the barite, therefore allowing it to function as a pigment.

The glass industry uses barite to increase the workability of glass, to act as a flux, assist decolouration and increase the brilliance or lustre of the product. Specifications call for a minimum of 96 to 98 per cent $BaSO_4$, a particle size range of 40 to 140 mesh and usually a magnetically separated ore is used with iron often reduced to 0.1 per cent. However, producers of fine glassware use precipitated barium carbonate to circumvent impurity problems often associated with natural barite.

The specifications for natural barite used as a filler in rubber goods vary, but the main factors are whiteness and particle size range. For general filler and extender uses most manufacturers want a product that is virtually all minus 325 mesh. Colour is important to many users.

## OUTLOOK

The demand in 1985 for barite is expected to increase based on recent strength in oil- and gas-well drilling activity. In 1984 9,149 wells or 10.4 million m were drilled in Canada according to preliminary statistics. This compares with 7,064 wells drilled or 8.3 million m drilled in 1983. In the medium- to long-term, factors influencing exploration and development activity include, the expected financial returns from exports of natural gas, the timing and nature of cooperative agreements on offshore ownership and the relative level of activity in the conventional source and offshore regions.

With more delineation drilling needed to confirm reserves offshore, additional supplies of barite will be needed. There is good potential for discovery and development of barite deposits in most regions; in Nova Scotia and Newfoundland several companies are involved at various stages of property development from drilling to small-scale production. However, sources from abroad will likely continue to compete with domestic producers as long as excess capacity and low ocean-freight rates prevail.

## PRICES

United States prices of barite as reported in Engineering and Mining Journal[1], of December 1984.

| | $ per short ton |
|---|---|
| Unground | |
| Chemical and glass grade: | |
| Hand picked, 95% $BaSO_4$, not over 1% Fe | 90.00 |
| Magnetic or flotation, 96-98% $BaSO_4$, not over 0.5% Fe | 106.00 |
| Imported drilling mud grade, specific gravity 4.20 - 4.30, cif Gulf ports | 32.00-50.00 |
| Ground | |
| Water ground, 95% $BaSO_4$ 325 mesh, 50-lb bags | 80.00-165.00 |
| Dry ground, drilling mud grade, 83%-93% $BaSO_4$, 3-12% Fe, specific gravity 4.20-4.30 | 55.00-115.00 |
| Imported | |
| Specific gravity 4.20-4.30 | 55.00-75.00 |

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[1] Published by McGraw-Hill.

## CELESTITE

## SUMMARY

There has been no Canadian production of celestite ($SrSO_4$), the main source of strontium, since Kaiser Celestite Mining Limited, a subsidiary of Kaiser Aluminum & Chemical Canada Investment Limited, closed its mining operation at Loch Lomond, Nova Scotia and its strontium products plant at Point Edward, Nova Scotia, in 1976.

## NORTH AMERICAN SCENE

North American consumers continue to depend totally on imports of strontium minerals. The strontium mining industry in the United States has been dormant since 1959 and Mexico and West Germany are the major suppliers of celestite and strontium compounds to the U.S. market.

Consumption of strontium compounds in the United States in 1984 was an estimated

24 000 t valued at $US 15.9 million. In 1984, one of the two major U.S. strontium compound producers closed its barium/strontium carbonate plant. From a 1979 base, demand for strontium in the United States is expected to increase at an annual rate of about 1.2 per cent through 1990, according to the United States Bureau of Mines.

## USES

Celestite is used to produce commercial strontium compounds, principally strontium carbonate and strontium nitrate. In the sulphate form it is used for purifying electrolytic zinc. Strontium carbonate is primarily used in glass faceplces for colour television picture tubes where it improves the absorption of X-rays emitted by the high voltage tubes. Other uses include pyro-technics and signals, and ferrite ceramic permanent magnets used in small electric motors.

## PRICES

United States prices of celestite according to Chemical Marketing Reporter, December 24, 1984

| | $ per short ton |
|---|---|
| Strontium carbonate glass grade, bags, truckload, works | $ 655.00 |
| | ($ per 100 pounds) |
| Strontium nitrate, bags, carlot, works | $ 24.00 |

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| CANADA | | | | (%) | |
| 49205-1 | Drilling mud and additives | free | free | free | free |
| 68300-1 | Barytes | free | 10 | 25 | free |
| 92818-1 | Barium oxide, hydroxide peroxide | 9.4 | 7.5 | 25 | 5 |
| 92842-1 | Barium carbonate | 10 | 13.8 | 25 | 9 |
| 93207-5 | Lithopone | free | 11.5 | 25 | free |

| MFN REDUCTIONS UNDER GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 92818-1 | 7.5 | 5.6 | 3.8 | 1.9 | free |
| 92842-1 | 13.8 | 13.4 | 13.1 | 12.8 | 12.5 |
| 93207-5 | 11.5 | 11.3 | 11.0 | 10.8 | 10.5 |

UNITED STATES (MFN)

| | | |
|---|---|---|
| | Barium carbonate: | |
| 472.02 | Natural, crude (witherite) | free |
| 472.06 | Precipitated | 0.5¢ per pound |
| | Barium sulfate: | |
| 472.10 | Natural, crude (barytes) | $1.27 per ton |
| 472.12 | Natural, ground (barytes) | $3.25 per ton |
| 472.14 | Precipitated (blanc fixe) | 0.2¢ per pound |
| 473.72 | Lithopone | 2.5% |
| 473.74 | Lithopone | 4.6% |

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 472.04 | Barium carbonate, natural ground (witherite) | 5.1 | 4.9 | 4.7 | 4.4 | 4.2 |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise. Tariff Schedules of the United States Annotated 1983, USITC Publication 1317. U.S. Federal Register Vol. 44, No. 241.

## TABLE 1. CANADA, BARITE PRODUCTION AND TRADE, 1982-84 AND CONSUMPTION, 1981 AND 1982

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Production** (mine shipments) | .. | 2 359 | 45 465 | 4,869 | 46 884<br>(Jan.-Sept. 1984) | 7,450 |
| **Imports** | | | | | | |
| United States | 8 558 | 1 185 | 4 602 | 697 | 5 254 | 501 |
| Ireland | 11 500 | 319 | 24 690 | 900 | - | - |
| Netherlands | 398 | 108 | 655 | 204 | 464 | 125 |
| Morocco | - | - | - | - | 10 593 | 890 |
| Other | 3 001 | 541 | 5 | 1 | - | - |
| Total | 23 457 | 2 153 | 29 952 | 1,802 | 16 311 | 1,516 |
| **Exports** | | | | | | |
| United States | 470 | 315 | 795 | 155 | 634 | 209 |
| United Kingdom | 6 | 4 | - | - | - | - |
| Japan | 6 | 12 | - | - | - | - |
| Total | 482 | 331 | 795 | 155 | 634 | 209 |
| | 1981r | | 1982P | | | |
| **Consumption**[1] | | | | | | |
| Well drilling[e] | 89 622 | | 20 000 | | | |
| Rubber goods | 1 192 | | 946 | | | |
| Paint and varnish | 1 598 | | 1 737 | | | |
| Other[2] | 1 585 | | 2 794 | | | |
| Total[e] | 93 997 | | 25 477 | | | |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Available data reported by consumers with estimates by Energy, Mines and Resources Canada. Does not include inventory adjustments. [2] Other includes bearings and brake linings, chemicals, floor covering, adhesives, explosives, asbestos products, etc.
P Preliminary; r Revised; e Estimated; .. Not available; - Nil.

## TABLE 2. CANADA, BARITE PRODUCTION TRADE AND CONSUMPTION, 1970, 1975, AND 1980-84

| | Production[1] | Imports | Exports | Consumption$^{e}$ |
|---|---|---|---|---|
| | ($) | | (tonnes) | |
| 1970 | 1,388,125 | 6 827 | 90 305 | 50 106 |
| 1975 | 2,305,819 | 4 479 | 45 606 | 40 229 |
| 1980 | 4,380,000 | 45 157 | 645 | 138 829 |
| 1981 | 5,124,000 | 16 278 | 405 | 94 027 |
| 1982 | 2,359,000 | 23 457 | 482 | 25 477 |
| 1983 | 4,869,000 | 29 952 | | .. |
| 1984P (9 mos.) | 7,450,000 | 16 311 | | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Mine shipments.

P Preliminary; $^{e}$ Estimated; .. Not available.

## TABLE 3. WORLD PRODUCTION OF BARITE 1981-83[1]

| Country[2] | 1981 | 1982P | 1983$^{e}$ |
|---|---|---|---|
| | | (tonnes) | |
| Afghanistan[3] | 1 | 2 | 2 |
| Algeria | 89 | 102 | 109 |
| Argentina | 49 | 36 | 40 |
| Australia | 41 | 40$^{e}$ | 40 |
| Belgium$^{e}$ | 40 | 40 | 40 |
| Bolivia[4] | 2 | 1 | 1 |
| Brazil | 116 | 120$^{e}$ | 118 |
| Burma[5] | 10$^{e}$ | 20 | 20 |
| Canada$^{e}$ | 80 | 30 | 28 |
| Chile | 259 | 292 | 300 |
| China$^{e}$ | 798 | 898 | 1 000 |
| Colombia | 4 | 4$^{e}$ | 4 |
| Czechoslovakia | 61$^{e}$ | 61$^{e}$ | 61 |
| Egypt | 2 | 3$^{e}$ | 4 |
| France | 191 | 156 | 150 |
| Germany, Democratic Republic$^{e}$ | 35 | 35 | 35 |
| Germany, Federal Republic | 165 | 362 | 250 |
| Greece[6] | 47 | 47 | 46 |
| Guatemala | 5 | 2 | 2 |
| India | 354 | 326 | 300 |
| Iran$^{e}$ | 75 | 80 | 85 |
| Ireland | 260$^{e}$ | 260$^{e}$ | 218 |
| Italy | 177 | 180 | 150 |
| Japan | 56 | 60 | 70 |
| Kenya | 6$^{e}$ | - | - |
| Korea, North$^{e}$ | 100 | - | - |
| Malaysia | 19 | 25$^{re}$ | 20 |
| Mexico | 318 | 364 | 350 |
| Morocco | 465 | 538 | 275 |
| Pakistan | 24 | 26 | 28 |
| Peru | 409 | 375 | 163 |
| Philippines | 2 | 9$^{e}$ | 2 |
| Poland | 85 | 80$^{e}$ | 100 |
| Portugal | 1 | 1$^{e}$ | 1 |
| Romania | 79$^{e}$ | 78$^{e}$ | 78 |
| South Africa, Republic of | 3 | 4 | 6 |
| Spain | 53 | 50 | 50 |
| Thailand | 307 | 331 | 188 |
| Tunisia | 25 | 31 | 20 |
| Turkey | 186 | 107 | 80 |
| U.S.S.R.$^{e}$ | 508 | 517 | 517 |
| United Kingdom | 63 | 81 | 85 |
| United States[7] | 2 585 | 1 674 | 684 |
| Yugoslavia | 45 | 45$^{e}$ | 40 |
| Total | 8 200 | 7 493 | 5 760 |

Source: United States Bureau of Mines.

[1] Table includes data available through May 30, 1984. [2] In addition to the countries listed, Bulgaria also produces barite, but available information was inadequate to make reliable estimates of output levels. [3] Year beginning March 21 of that stated. [4] Series represents exports only. Bolivia also produces barite for domestic consumption, but available data are not adequate for formulation of estimates or levels of production to meet internal needs. [5] Data are for fiscal years beginning April 1 of that stated. [6] Barite concentrates. [7] Sold or used by producers.

$^{e}$ Estimated; P Preliminary; $^{r}$ Revised.

# Berryllium

G. BOKOVAY

Beryllium is a gray corrosion - resistant metal with a specific gravity of 1.85, which is between that of aluminium and magnesium. The metal has a tensile strength considerably greater than either of these two metals, a good modulus/density ratio, a high melting point (1290°C), elevated temperature strength and excellent nuclear moderating and reflecting properties.

While there has been no discernible trend in beryllium consumption during the last 15 years, demand for the metal should increase in view of the expected increase in utilization of beryllium - copper alloys in the electrical and electronics industries.

Although Canada does not produce either beryllium metal or beryllium minerals, this situation could change in the next decade in light of recent discoveries of relatively high-grade beryllium mineralization. Expected growth in beryllium demand along with the apparent desire of the United States to conserve its domestic sources of supply for the metal, could encourage development of some of these resources.

## PRODUCTION OF BERYLLIUM MINERALS

Beryllium is produced commercially from two minerals, beryl and bertrandite. Beryl ($3BeO.Al_2O_3.6SiO_2$), which occurs in pegmatite dykes, is hand picked and cobbed to remove gangue minerals adhering to the beryl crystals. The separation of beryl by mechanical or flotation techniques is difficult because the densities of beryl and associated minerals are similar. Since beryl production is labour intensive, beryl is principally mined in developing countries. The People's Republic of China and Brasil are considered to be the most important producers.

Beryl has been mined in Canada although there has been no production in recent years.

Bertrandite ($Be_4\ Si_2\ O_7\ (OH)_2$), which has been mined in the United States since 1969 by Brush Wellman Inc., has become the most important source of beryllium metal in the western world. The company operates an open pit bertrandite mine in the volcanic tuff beds of the Topaz - Spor Mountain area of western Utah.

World reserves of beryllium minerals are very large in relation to current rates of extraction. At the end of 1983, Brush Wellman estimated its bertrandite ore reserves at about 4.5 million t grading approximately 0.22 per cent beryllium. At the current mining rate of about 105 000 tpy, these reserves would last about 40 years. World reserves outside China, which are estimated by Roskill Information Services at 419 000 t of contained beryllium, could satisfy current beryllium consumption for a thousand years.

## CANADIAN DEVELOPMENTS

In recent years, important discoveries of beryllium minerals have been made in Canada. At Thor Lake, which is located about 65 miles southeast of Yellowknife, Northwest Territories, Highwood Resources Limited has discovered a significant deposit of the mineral phenacite ($BeSiO_4$) as well as niobium, tantalum, zirconium, columbium and rare earths. To date, drilling on the "T" zone has defined 435 000 t grading 1.4 per cent BeO while 1 200 000 t grading .66 per cent BeO has been identified in the "South" zone.

Highwood is currently undertaking a pre-feasibility study, including metallurgical testing, to assess the economic viability of an open pit beryllium mine and concentrator at the site.

At a mining rate of about 225 tpd of ore and an expected recovery rate of 85 to

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90 per cent, the company plans to produce about 3 000 tpy of concentrate containing about 10-13 per cent BeO. Since the beryllium ore also contains yttrium, a separate circuit for this metal is being considered.

It is reported that the Dene Nation in the Northwest Territories is opposed to the potential development. The probable minesite is located on lands which are subject to a native land claims settlement that is being negotiated between the federal government and the Dene Nation.

In 1984, Bearcat Explorations undertook an exploration program at its 80 per cent owned Hellroaring Creek property near Kimberly, British Ccolumbia, where the mineral phenacite has also been identified. Exploration in the 1960s identified about 500 000 t of ore averaging about 1 per cent BeO.

At Strange Lake on the Quebec - Labrador border, the Iron Ore Company of Canada (IOC) in 1979 discovered a high grade deposit of yttrium and zirconium which also contains columbium, beryllium and rare earth elements. The deposit is reported to be amenable to open pit mining. Although IOC has undertaken market studies and metallurgical testing, no decision has apparently been made regarding future development of the deposit.

## WORLD PRODUCTION AND DEVELOPMENTS

The Unites States and the U.S.S.R. are the only known producers of beryllium metal, although it is suspected that the Peoples Republic of China is also a producer. Production data for the United States is withheld to conform with confidentiality regulations, since Brush Wellman Inc. is the sole producer.

In the United States, Brush Wellman produces beryllium hydroxide at a plant at Delta, Utah, from bertrandite concentrate from the company's nearby open-pit mines and from imported beryl ore. Some of the ore is processed on a toll basis for Cabot Corporation. The output of the Delta plant, which is impure beryllium hydroxide, is sent to the company's Elmore Ohio plant for further processing.

At Delta, a new beryl furnace designed to handle lower grade beryl ore (7 per cent BeO) was brought on-stream in 1984. However, certain technical problems arose that forced the company to restart its old beryl furnace.

In response to increased beryllium demand, Brush Wellman has in recent years been increasing the amount of imported beryl processed at its Delta plant. However, with reports that the company has reduced its purchases on the spot market, beryl consumption in 1984 will probably be equal to or lower than in 1983.

In 1984, Brush Wellman announced that a new bulk product plant would be built at Elmore, Ohio to produce Be-Cu rod and tubular products. In addition the company also plans to expand extrusion and billet capacity. Brush also announced plans for a $US 57 million expansion that will almost double it Be-Cu strip capacity. This includes a $30 million casting, rolling, pickling and annealing unit at Elmore, $10 million for additional strip finishing and improvement to existing capacity at Reading, Pa and $15 million for a finishing mill in Europe. During 1984, the Cabot Wrought Product Division of Cabot Corporation brought a new wide strip Be-Cu finishing unit at Elkhart, Ind. into production. At the time of the company's announcement, the backlog of customer orders was about 30 weeks.

In 1984, Brush Wellman Inc. announced an expansion to its beryllia ceramic production facility at Tucson, Arizona. The expansion, which was expected to be completed by the end of 1984, will increase capacity by 50 per cent.

Exposure to small concentrations of beryllium dust has been recognized as the cause of berylliosis, a serious chronic lung disorder. More restrictive exposure limits were first proposed in the United States in 1975. These proposals were strongly opposed by the U.S. industry on the grounds that they were technically impossible to meet. To date, changes to U.S. regulations have not been implemented.

## USES

Although beryllium metal and its intermediates are relatively expensive, its unique properties have found application in a wide range of goods, although in small quantities. The consumption of beryllium in metal, alloy and oxide forms is estimated as

40 per cent in nuclear reactors and aerospace applications, 36 per cent for electrical equipment, 17 per cent for electronic equipment and 7 per cent for miscellaneous uses. It is estimated that 75 per cent of the beryllium is consumed in beryllium alloys principally beryllium-copper, 17 per cent as beryllium metal while 8 per cent is consumed as beryllium oxide.

Beryllium copper alloys which consume a major portion total beryllium produced, may contain anywhere from 0.25 to 2.15 per cent beryllium. In general, beryllium-copper alloys are much stronger and harder than pure copper, and still have good electrical conductivity. In addition these alloys have good corrosion resistance and low magnetic susceptibility.

A list of applications for wrought or a Be-Cu alloys include: precision mechanical and electro mechanical springs; electrical/electronic connectors, sockets, contacts, relays, and switches; diaphrams; dies; injection molds for plastics; non sparking tools; undersea cable housings; bushings; welding tips; and certain applications in oil and gas drilling housings, measurement systems and drill string components. In the United States, Be-Cu master alloys and products are supplied by Brush Wellman Inc. and Cabot Corporation.

Brush's beryllium - nickel alloys have many of the same properties as Be-Cu alloys except that they can be used in higher temperature applications for miniature electronic connector components, springs and mechanical fasteners.

In 1984, Brush introduced a new family of copper alloys containing small amounts of beryllium and cobalt. These alloys, which will be used in the electronic and electrical industries, will compete with phosphar bronze and similar copper alloys.

When beryllium is added to aluminum or magnesium, the resultant alloys are known to more easily fabricated than the host metals and have improved oxidation resistance. Although proven uses are few, (Be-Al alloys have been used in certain aerospace applications and for cooking utensils) these alloys offer some potential for increased beryllium consumption in the future.

Beryllium has also been identified as a potentially useful additive to high-tensile stainless steels although current production is thought to be limited.

For products made of beryllium metal, powder metallurgy is the preferred method of fabrication since coarse crystals develop when the metal is cast. Use of this expensive metal is justified by its superior strength and stiffness relative to density in structural aerospace applications, inertial guidance system components, space borne optics and aircraft brakes.

Beryllium metal's high moderating ratio and high neutron reflection properties have led to its use in nuclear aplications despite embrittlement after long exposure to radiation.

Beryllium oxide ceramics have excellent insulating properties, high thermal conductivity and thermal shock resistance. Applications include high density electronic circuits, radar, electronic counter-measure systems, cellular radiotelephone systems, microwave communication equipment, graphic lasers, computerized tomography scanners, automotive ignition systems and microwave ovens.

## STOCKPILES

Beryllium is of strategic importance and the U.S. General Services Administration (GSA) maintains the metal in its National Defense Stockpile. During 1984, the GSA took delivery of 60 000 pounds of beryllium metal and has contracted a similar amount for delivery in 1985.

The USBM reported that at the end of 1983, the GSA held over 16 000 t of beryl ore, 208 t of beryllium metal and 6 700 t of beryllium-copper master alloy (4 per cent Be).

## OUTLOOK

Demand for beryllium metal was strong in 1984 and is expected to remain strong in 1985. For the first 9 months of 1984, Brush Wellman's sales of beryllium and other specialty metals rose 40 per cent from 1983, to $US 195.5 million. The company also reported that order back-logs were at an all-time high.

The highest long-term growth for beryllium is expected to be in beryllium copper alloys in both the wrought and cast sectors. However, the movement to miniaturization in the electronics industry could be a limiting factor.

Although the outlook for beryllium metal and beryllium oxide is somewhat less optimistic than for beryllium alloys, growth is nevertheless expected. Expansion of the electronics industry will result in increased demand for beryllium ceramics while increased utilization of the metal is expected in the aerospace industry.

Overall, demand for beryllium in all forms is expected to grow at between 4 and 5 per cent annually until the mid 1990s. Since a significant portion of beryllium metal production is consumed in the form of defense related products, overall beryllium demand has fluctuated in response to defense contracts. Although these fluctuations can be expected to continue, the growing share of beryllium utilized in alloy form in non-defense applications should help to stabilize overall consumption.

**TARIFFS**

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | % | | |
| CANADA | | | | | |
| 34907-1 | Copper beryllium alloys | 4.6 | 4.5 | 25 | free |
| 35101-1 | Beryllium metal | free | 4.5 | 25 | free |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | % | | |
| 34907-1 | 4.5 | 4.4 | 4.3 | 4.1 | 4.0 |
| 35101-1 | 4.5 | 4.4 | 4.3 | 4.1 | 4.0 |

UNITED STATES (MFN)

| | | |
|---|---|---|
| 417.90 | Beryllium oxide or carbonate | 3.7% |
| 601.09 | Beryllium ore | free |
| 628.05 | Unwrought beryllium, waste and scrap | 8.5% |
| 628.10 | Beryllium, wrought | 9.0% |

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | % | | |
| 612.20 | Beryllium copper master alloy | 8.3 | 7.7 | 7.2 | 6.6 | 6.0 |
| 417.92 | Other beryllium compounds | 4.4 | 4.2 | 4.0 | 3.9 | 3.7 |

Sources: The Customs Tariff, 1983 Revenue Canada, Customs & Excise; Tariff Schedules of the United States Annotated (1983), USITC Publication 1317; U.S. Federal Register, Vol. 44, No. 241.

### TABLE 1. ESTIMATED WORLD BERYLLIUM PRODUCTION[1]

| | 1980 | 1981 | 1982 | 1983 | 1984e |
|---|---|---|---|---|---|
| | | | (tonnes) | | |
| United States | | | | | |
| from Bertradite[2] | 143.6 | 144.4 | 105.8 | 135.0 | 150 |
| from Imported beryl[3] | 39.8 | 49.9 | 61.9 | 51.2 | 50 |
| Total | 183.4 | 194.3 | 167.7 | 186.2 | 200.0 |
| U.S.S.R.[3] | 46.7 | 46.7 | 46.7 | 49.0 | 50.0 |
| Total[4] | 230.1 | 241.0 | 214.4 | 235.2 | 250.0 |

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[1] Includes the beryllium metal equivalent of beryllium alloys and oxide. [2] Beryllium content of concentrate produced as reported by Brush Wellman Inc. 1983 Annual Report - 65 per cent recovery of metal assumed. [3] Reported by USBM, 1983 Beryllium preprint - 65 per cent recovery of metal from beryl assumed. [4] Excludes China.

### TABLE 2. PRICES ($US)

| | |
|---|---|
| Beryl ore; Cif Atlantic - Ports 10% to 12% per Stu. (Eff. 19/4/82) | $90.00 - $130.00 |
| Beryllium oxide<br>Uox powder GCR, GCHG (Brush Wellman) (Eff. 23/1/84) | $52.50 |
| **Beryllium** (containing alloys; 4% BeCu) | |
| 275 C BeCu casting alloy (10-1-84)... | $5.55 |
| 165 C BeCu casting alloy (10-1-84)... | $4.95 |
| 245 BeCu casting alloy (10-1-84)..... | $5.30 |
| 10C BeCu casting alloy (10-1-84)..... | $4.95 |
| (Containing less than 0.5 per cent Mg) | |
| Per lb. contained beryllium .......... | $140 |
| **Beryllium 97%** | |
| Powder blend (200 grade) | |
| 5 000 lb. lots (Eff. 14-2-84)...... | $178 |
| Vac. cast ingots (Eff. 6-2-84)..... | $213 |
| fob Elmore, Ohio | |
| **Beryllium aluminum** (1-4-84) | |
| fob Reading, Pa., Detroit and Elmore, Ohio (100,000 lb)........... | $230 |
| **Beryllium copper** (10-1-84) | |
| Strip (No.25)...................... | $7.10 |
| Rod, bar and wire (No.25).......... | $7.60 |
| **Beryllium copper master alloy** | |
| fob Reading, Pa., Detroit, Michigan, Elmore, Ohio, per lb. contained beryllium for 5 lb. ingot (Eff. 10-1-84)............... | $140 |

+ Beryllium copper alloys reflect a $1 per pound base copper price. Prices will fluctuate weekly based on a predetermined copper composite price chosen by the individual companies.

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Source: American Metal Market.

# Bismuth

J. BIGAUSKAS

## INTRODUCTION

Bismuth (chemical symbol Bi), is generally produced as a byproduct of some lead, copper and tin mines in various parts of the world. The important bismuth-bearing minerals are: bismite, an oxide; bismuthinite or bismuth glance, sulphides; bismutite, a carbonate. The abundance of bismuth in the earth's crust is estimated to be 0.00002 per cent - about the same as silver or cadmium.

Most of bismuth in copper concentrates accompanies the copper matte during smelting. In the conversion of copper matte to blister copper, most of the bismuth is fumed and subsequently collected in the baghouse with lead, arsenic or antimony. These dusts are then processed by lead smelters.

Bismuth in lead concentrates stays with the impure lead bullion during reduction in the blast furnace. The first stages of pyrometallurgical refining produce a bismuth-containing dross and then a bismuth-lead alloy which may be refined further to remove impurities, precious metals and remaining lead and zinc. Finally, bismuth is given a final oxidation with air and caustic soda or chlorine to yield a product with final purity of 99.99+ per cent.

Alternatively, at electrolytic lead refineries, treatment of lead anodes leaves pure lead on the cathode and a cell slime. The slime is processed to yield an impure metal, and then the metal is refined. Bismuth is leached from roasted tin concentrates with hydrochloric acid, precipitated as bismuth oxychloride, reduced to metal by wet or dry methods and then refined further.

## CANADIAN DEVELOPMENTS

Bismuth metal is recovered at Cominco Ltd.'s Trail, British Columbia electrolytic lead refinery and is refined to 99.99+ per cent purity. Some bismuth is refined further at Cominco Electronic Materials Division for use in electronics and research applications. The ores of the Sullivan mine, the major source of lead concentrate feed to the smelter/refinery, contain traces of bismuth.

Bismuth-lead alloys are produced at Brunswick Mining and Smelting Corporation's pyrometallurgical lead refinery at Belledune, New Brunswick. Most feed is from the Brunswick No. 12 mine in the form of a lead concentrate with small amounts of contained bismuth.

Bismuth concentrates are also produced at Terra Mines Ltd.'s Silver Bear operations in the Northwest Territories. Total production of bismuth in Canada in 1984 was approximately 220 t, 33 t less than in 1983.

Consumption of bismuth in Canada dropped in 1983 to about 7 t from 10 t in previous years. Consumption was expected to be slightly higher in 1984.

## WORLD DEVELOPMENTS

Western world consumption of bismuth can only be estimated, since statistical coverage is incomplete. Preliminary estimates indicate that Japanese consumption rose from 339 t in 1983 to nearly 500 t in 1984. Consumption in the United States, the largest market, likely showed a substantial increase perhaps to 1 500 t, due partly to broader survey coverage. European consumption was estimated to be around 1 000 t while consumption in other countries likely totalled several hundred tonne in 1984.

Reported metal exports to socialist countries totalled about 400 t in 1984. These included Peru's 200 t sale of bismuth to the People's Republic of China in May and a further 200 t sale to the U.S.S.R. in August.

Major western world mine producers of bismuth-containing ores and concentrates are

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Australia, Mexico, Peru, Canada and Japan. These countries produce bismuth from a variety of ores which may contain lead, silver, copper or zinc. Bolivia until 1980 produced from bismuth ores, but now primarily produces byproduct bismuth in other ores.

Major western world producers of byproduct bismuth at the smelting and refining stage are Mexico, Japan, Peru, the United Kingdom, Bolivia, Canada, United States, the Federal Republic of Germany, France and Belgium.

Production of refined bismuth at the refining stage can be highly variable from year to year because of the byproduct nature of production. Estimated western world production of refined bismuth in 1984 was about 3 300 t.

Technical problems at Met-Mex Penoles S.A.'s Torreon, Mexico refinery in February, 1984 made it necessary to reprocess material to meet specifications. This resulted in at least a one month delay in shipments. However, the company expected to produce its full 500 t capacity for 1984, despite this problem and despite a reported interruption in bismuth production in May.

Domestic production of bismuth metal in Japan, according to MITI estimates, was expected to have remained stable at close to 580 t in 1984 compared to 569 t in 1983. Bismuth exports, however, were expected to have fallen to 150 t in 1984, from 248 t in 1983.

Minpeco, the metal marketing company of Peru, declared a **force majeure** on bismuth needles early in the year because of flooded road and rail links. Although the **force majeure** was lifted in mid-May, shipments bound for the United States did not arrive until June.

Peko-Wallsend Ltd. of Australia cut back its mine production of bismuth substantially in 1981 because of declining prices but potentially could increase output given higher and sustained prices for its major products, copper and gold, at its Tennant Creek, Australia operation. Bismuth is also contained in small amounts in lead concentrates and is removed as crusts during refining of lead. Australia is the western world's second largest mine producer of lead.

In the United Kingdom, Mining & Chemical Products Ltd. (MCP) still processed bismuth ores and bullion to 99.99 per cent and 99.997 per cent refined metal grades for metallurgical and pharmaceutical purposes, respectively. Since production in Bolivia was curtailed in 1980 and since output from Peko-Wallsend in Australia was reduced, a drop in MCP's production to a level of a "few hundred tonnes per year" has been reported by the company.

Improving conditions in the bismuth market led Mines et Produits Chimiques de Salsigne of France to make a decision to return to bismuth production in March 1985 at an expected 100 tpy. In 1979 annual mine output was estimated at 60 tpy bismuth from a complex ore principally mined for its gold content. The company has been selling metal from stocks accumulated at its nearby smelter.

In Bolivia, the new lead-silver smelter of Corporacion Minera de Bolivia (Comibol) and Empresa Nacional de Fundiciones (ENAF) did not produce in 1984 because of a lack of feed. In addition to some 24 000 tpy of lead, the plant is expected to produce some bismuth. Since output was curtailed at Bolivia's bismuth mines in 1980, production has been limited to byproduct bismuth largely associated with tin.

Restarting of Comibol's bismuth refinery is contingent on a market assessment which is expected by February 1985. Resumption of operations at the refinery and at the Quechista mine could be as early as March. Some 200 t of bismuth could be produced in 1985 and perhaps 500 tpy thereafter.

ASARCO Incorporated is the only refined bismuth producer in the United States. Production is largely a byproduct from the processing of imported complex lead concentrates and domestic concentrates and materials which contain bismuth.

## PRICES

Reported major sales of bismuth metal by Peru to the Soviet Union and to the People's Republic of China depleted stocks and set the stage for notable price increases later in 1984.

The MCP-Peko Limited published producer price in Europe and the United States remained at $2.30/lb throughout 1983 and up until March 15, 1984. Thereafter it rose to $US 6.50 per pound. The European Free Market price averaged about $US 1.60 per pound in 1983 but climbed steadily from a level of $US 1.75-1.79 at the beginning of 1984 to $US 6.40-6.55 by year-end.

## USES

Bismuth is used in a wide variety of applications. Fusible alloys - bismuth alloyed with tin, lead, and cadmium, for example - melt at low temperatures. They are reusable for applications such as blocking complex shapes for machining; grinding and polishing of lenses; and die assembly. These alloys are also used as moulds for plastic extrusion, as filler for tube-bending, as solder alloys, and as thermal fuses.

Bismuth is added to iron, steel and aluminum to improve machineability. Bismuth compounds are used in pharmaceuticals, cosmetics and chemicals. For example, bismuth salts are used as a treatment for indigestion and stomach ulcers. Bismuth oxychloride, either deposited on mica or in dispersed form, provides a pearlescent lustre to lipsticks, face powders, blushes, nail color, eyeshadow and hairspray. Catalysts containing bismuth are also used for production of acrylonitrile and acroleine.

Research is on-going for possible uses in thin metallic films for optical disk information storage; in immiscible alloys for data storage; in an organometallic fungicide; in silver-bismuth oxide electric contact material and in lithium-silver bismuth chromate battery cells.

## OUTLOOK

A production shortfall of at least 200 t is predicted by some experts for 1985. If true, bismuth prices can be expected to rise further in the short-term. On the other hand, substitution particularly in chemical and pharmaceutical applications is likely to be relatively rapid and this may dampen a price rise. The possibility of resumed production in Bolivia and France in 1985 also suggests that a sustained high price is unlikely.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General Preferential | General |
|---|---|---|---|---|---|
| CANADA | | | | | |
| 33100-1 | Bismuth, metallic, in its natural state | free | free | free | free |
| 35106-1 | Bismuth metal, not including alloys, in lumps, powders, ingots or blocks | free | free | free | 25% |

| UNITED STATES (MFN) | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 601.66 | Bismuth ores | Remains free | | | | |
| 632.10 | Bismuth metal unwrought and waste and scrap | Remains free | | | | |
| 632.64 | Alloys of bismuth: containing by weight not less than 30 per cent lead | Remains free | | | | |
| 632.66 | Other alloys of bismuth | 7.3 | 6.8 | 6.4 | 5.9 | 5.5 |
| 633.00 | Bismuth metal wrought | 7.3 | 6.8 | 6.4 | 5.9 | 5.5 |

Sources: The Customs Tariff, 1983, Revenue Canada; Customs and Excise; Tariff Schedules of the United States Annotated 1982, USITC Publication 1200; U.S. Federal Register Vol. 44, No. 241.

**TABLE 1. CANADA, BISMUTH PRODUCTION, 1983-84, AND CONSUMPTION, 1981-1983**

| | 1983 | | 1984 | |
|---|---|---|---|---|
| | (kilograms) | ($) | (kilograms) | ($) |
| **Production,** all forms[1] | | | | |
| New Brunswick | 165 608 | 847,400 | 159 000 | 1,879,380 |
| British Columbia | 47 427 | 215,319 | 36 134 | 427,104 |
| Ontario | 8 105 | 41,472 | - | - |
| Northwest Territories | 31 883 | 163 142 | 24 500 | 289,590 |
| Total | 253 023 | 1,267,333 | 219 634 | 2,592,074 |

| | 1981 | 1982 | 1983 |
|---|---|---|---|
| | | (kilograms) | |
| **Consumption,** refined metal (available data) | | | |
| Fusible alloys | 7 547 | 7 598 | 7 241 |
| Other uses | 2 547 | 2 476 | 1 019 |
| Total | 10 094 | 10 074 | 7 241 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported.

P Preliminary; - Nil.

**TABLE 2. CANADA, BISMUTH PRODUCTION AND CONSUMPTION, 1970, 1975 AND 1978-84**

| | Production all forms[1] | Consumption[2] |
|---|---|---|
| | (kilograms) | |
| 1970 | 267 774 | 11 135 |
| 1975 | 156 605 | 29 267 |
| 1978 | 145 104 | 25 665 |
| 1979 | 136 733 | 25 177 |
| 1980 | 149 366 | 10 271 |
| 1981 | 167 885 | 10 094 |
| 1982 | 189 000 | 10 074 |
| 1983 | 253 023 | 7 241 |
| 1984P | 219 634 | .. |

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported. [2] Refined bismuth metal reported by consumers.

P Preliminary; .. Not available.

**TABLE 3. UNITED STATES CONSUMPTION OF BISMUTH BY PRINCIPAL USES, 1981-83**

| | 1981 | 1982 | 1983 |
|---|---|---|---|
| | (kilograms, bismuth content) | | |
| Pharmaceuticals[1] | 629 384 | 519 250 | 500 640 |
| Metallurgical additives | 139 266 | 56 532 | 237 144 |
| Fusible alloys | 297 990 | 259 277 | 282 491 |
| Other alloys | 11 772 | 9 700 | 9 072 |
| Experimental uses | 97 | 223 | 762 |
| Other uses | 6 806 | 6 148 | 6 472 |
| Total | 1 085 315 | 851 130 | 1 036 581 |

Source: U.S. Bureau of Mines.

[1] Includes industrial and laboratory chemicals.

TABLE 4. MONTHLY AVERAGE PRICES - BISMUTH

| | 1982 | 1983 | 1984 |
|---|---|---|---|
| | (Major producer, $US per pound) | | |
| January | 2.30 | 2.30 | 2.30 |
| February | 2.30 | 2.30 | 2.30 |
| March | 2.30 | 2.30 | 2.49 |
| April | 2.30 | 2.30 | 2.75 |
| May | 2.30 | 2.30 | 3.59 |
| June | 2.30 | 2.30 | 4.00 |
| July | 2.30 | 2.30 | 4.00 |
| August | 2.30 | 2.30 | 4.72 |
| September | 2.30 | 2.30 | 5.00 |
| October | 2.30 | 2.30 | 5.54 |
| November | 2.30 | 2.30 | 6.50 |
| December | 2.30 | 2.30 | 6.50 |
| Year | 2.30 | 2.30 | 4.14 |

Source: Metals Week.

# Cadmium

**M.J. GAUVIN**

Cadmium metal is recovered principally as a byproduct of zinc smelting and refining. In 1984 zinc metal production in the non-socialist world was at an all-time high surpassing the previous high reached in 1979. Similarly cadmium metal production in 1984 exceeded the previous high attained in 1979.

Cadmium is a relatively rare element in the earth's crust, occurring most commonly as the sulphides greenockite and hawleyite which are found associated with zinc sulphide ores, particularly sphalerite. There are no ores specifically mined for cadmium. Reserves at any time are a function of zinc reserves.

Smelter residues from which cadmium is extracted may be stockpiled in times of low demand with the result that refined cadmium production is not always directly related to production of the principal metals. During the past six years, cadmium production in Canada has varied from 2.1 to 2.6 kilograms of cadmium to each tonne (t) of zinc metal produced.

Cadmium metal is produced in varying shapes and degrees of purity for various uses. The most common forms are balls, sticks, slabs, ingots, rods and sponge.

In 1983 and 1984, Canada was the non-socialist world's third largest producer of cadmium metal, after Japan and the United States. The next three largest producers were Belgium, the Federal Republic of Germany and Australia. Production of cadmium in the non-socialist world, as reported by the World Bureau of Metal Statistics, increased in 1983 to 13 589 t from 12 733 t in 1982. While data is not yet available, 1984 non-socialist world production is estimated to increase about 7.8 per cent over that of 1983, and Canadian production is estimated at 1 500 t.

Consumption of refined cadmium in Canada, as reported by consumers to Statistics Canada, recorded a small decrease in 1982 to 33 818 kilograms from that reported in 1981. However, consumption, as measured by producers shipments to domestic consumers in 1984, is estimated at 120 000 kg during 1984 compared with 91 310 in 1983 a 7 per cent increase from that reported for 1982.

## USES

Cadmium is a soft, ductile, silver-white electropositive metal with a valence of two. It is used mainly for electroplating iron and steel products to protect them against oxidation. The high ductility of cadmium is an advantage where the plated parts are to be formed. The good soldering characteristics of cadmium plate is an advantage in electrical applications. A cadmium coating, like a zinc coating, protects metals that are lower in the electromotive series by physical enclosure and by sacrificial corrosion. Cadmium is usually preferred to zinc as a coating because it is more ductile, can be applied more uniformly in recesses of intricately shaped parts, has a more aesthetic appearance and gives greater protection with the same thickness of plating than with zinc plating.

The second largest use, according to the Statistics Canada survey, is in the manufacture of pigments and chemicals. Cadmium sulphides are used for yellow to orange colours and cadmium sulphoselenides for pink, red and maroon. Cadmium-containing pigments demonstrate good reflectance, heat stability and colour intensity. Cadmium compounds are used as stabilizers in the production of plastics, and cadmium phosphors are used for picture tubes in television sets.

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Cadmium-bearing batteries such as nickel-cadmium, silver-cadmium and mercury-cadmium, have the advantage of long life, maximum current delivery with a low voltage drop, small size, excellent performance under a wide temperature range and a low rate of self-discharge. They find wide use in aircraft, satellites, missiles, calculators, and a broad assortment of portable tools and appliances.

Other uses of cadmium are for catalysts in the production of primary alcohols and esters, low-melting point alloys used in fire detection, bearing alloys, brazing alloys and solders and copper hardeners for railway catenary and trolley wires.

## PRICES

North American prices, which are quoted on a delivered basis, are best represented by the "U.S. Producer" quotations published in Metals Week. European prices by the "European sticks, free market price" quoted by Metal Bulletin. All quoted prices are for cadmium having a minimum purity of 99.95 per cent.

Published U.S. producer prices were $1.00 a pound at the beginning of 1983, rising gradually to $1.25 a pound in September. This price held until March 1984 then peaked at $2.25 during the April to June period, dropped off to $1.55 a pound in August and then maintained that level for the balance of the year.

## OUTLOOK

In the long-term, cadmium supply will continue to be dependent on trends established by the zinc idustry. As the level of metal production is determined by the amount of zinc metal production, periods of oversupply will develop. It is expected that greater usage in its traditional markets and possible new uses would gradually absorb the excess supply.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| CANADA | | | | | |
| 32900-1 | Cadmium in ores and concentrates | free | free | free | free |
| 35102-1 | Cadmium metal, not including alloys, in lumps, powders, ingots, or blocks | free | free | 25 | free |
| UNITED STATES | | | | | |
| 601.66 | Cadmium in ores and concentrates | | free | | |
| 632.14 | Cadmium metal, unwrought, waste and scrap | | free | | |
| 632.86 | Cadmium alloys, unwrought containing by weight 96% or more but less than 99% of silicon | | 9% | | |

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | (%) | | | |
| 632.88 | Cadmium alloys, unwrought, other | 7.3 | 6.8 | 6.4 | 5.9 | 5.5 |
| 633.00 | Cadmium metal, wrought | 7.3 | 6.8 | 6.4 | 5.9 | 5.5 |

EUROPEAN ECONOMIC COMMUNITY (MFN)

| | | 1983 | Base Rate | Concession Rate |
|---|---|---|---|---|
| | | | (%) | |
| 26.01 | Cadmium in ores and concentrates | free | free | free |
| 81.04 | Cadmium metal, unwrought, waste and scrap | 4 | 4 | 4 |
| | Cadmium metal, other | 6 | 6 | 6 |

JAPAN (MFN)

| | | 1982 | Base Rate | Concession Rate |
|---|---|---|---|---|
| | | | (%) | |
| 26.01 | Cadmium in ores and concentrates | free | free | free |
| 81.04 | Cadmium metal: | | | |
| | Unwrought | 6.2 | 10 | 5.1 |
| | Waste and scrap | 6.0 | 10 | 4.8 |
| | Powders and flakes | 6.6 | 10 | 5.8 |
| | Cadmium metal, other | 8.6 | 15 | 6.5 |

Sources: The Customs Tariff and Commodities Index, January, 1983. Revenue Canada; Tariff Schedules of the United States Annotated 1983, USITC Publication 1317; U.S. Federal Register, Vol. 44, No. 241; Official Journal of the European Communities, L 318, Vol. 25; Customs Tariff Schedules of Japan, 1983.

TABLE 1. CANADIAN PRIMARY CADMIUM STATISTICS, 1981-84

| | 1981 | 1982 | 1983P | 1984e |
|---|---|---|---|---|
| | | (tonnes) | | |
| Mine production(1) | 834 | 886 | 1 107 | 1 200 |
| Metal production | 1 293 | 1 162 | 1 296 | 1 500 |
| Metal capacity | 1 800 | 1 800 | 1 800 | 1 800 |
| Metal shipments: | | | | |
| Domestic | 131 | 85 | 91 | 120 |
| Exports | 1 182 | 731 | 1 611 | 1 450 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary e Estimated; (1) All forms.

TABLE 2. CANADA, CADMIUM METAL CAPACITY, 1984

| Company and Location | Annual Capacity |
|---|---|
| | (tonnes) |
| Cominco Ltd. | |
| Trail, British Columbia | 640 |
| Canadian Electrolytic Zinc Limited | |
| Valleyfield, Quebec | 550 |
| KCML Inc. | |
| Hoyle, Ontario | 450 |
| Hudson Bay Mining and Smelting Co., Limited | |
| Flin Flon, Manitoba | 160 |
| Total Canada | 1 800 |

Sources: Mining & Mineral Processing Operations in Canada, 1983. Energy, Mines and Resources, Canada.

### TABLE 3. CANADA, CADMIUM PRODUCTION AND EXPORTS 1982, 1983, AND 1984 AND CONSUMPTION 1981 and 1982

| | 1982 | | 1983P | | 1984P | |
|---|---|---|---|---|---|---|
| | (kilograms) | ($) | (kilograms) | ($) | (kilograms) | ($) |
| **Production** | | | | | | |
| All forms[1] | | | | | | |
| Ontario | 549 006 | 1,663,000 | 834 000 | 2,551,000 | | |
| British Columbia | 147 656 | 447,000 | 136 000 | 418,000 | | |
| Quebec | 135 479 | 410,000 | 90 000 | 275,000 | | |
| Manitoba | 37 479 | 114,000 | 38 000 | 117,000 | | |
| Newfoundland | 9 818 | 30,000 | - | - | | |
| Saskatchewan | 6 617 | 20,000 | 9 000 | 27,000 | | |
| Total | 886 055 | 2,684,000 | 1 107 000 | 3,388,000 | .. | .. |
| Refined[2] | 1 162 390 | .. | 1 296 078 | .. | 1 500 000 | |
| **Exports** | | | | | | |
| | | | | | (January - September) | |
| United States | 378 645 | 1,161,000 | 776 432 | 2,978,000 | 610 415 | 2,663,000 |
| United Kingdom | 319 555 | 770,000 | 495 481 | 1,078,000 | 389 111 | 1,286,000 |
| Netherlands | 10 151 | 40,000 | 87 996 | 128,000 | 9 112 | 26,000 |
| Belgium-Luxembourg | 65 | 1,000 | 4 536 | 20,000 | 5 000 | 8,000 |
| Other countries | 61 114 | 154,000 | 666 | 28,000 | 343 | 38,000 |
| Total | 769 530 | 2,126,000 | 1 365 111 | 4,232,000 | 1 013 981 | 4,021,000 |

| | 1981 | 1982 |
|---|---|---|
| | (kilograms) | |
| **Consumption** | | |
| Cadmium metal[3] | | |
| Plating | 16 039 | 15 404 |
| Solders | 1 387 | 247 |
| Other uses[4] | 16 666 | 18 167 |
| Total | 34 092 | 33 818 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Production of refined cadmium from domestic ores, plus recoverable cadmium content of ores and concentrates exported. [2] Refined metal from all sources and cadmium sponge. [3] Available data reported by consumers. [4] Mainly chemicals, pigments and alloys other than solder.

P Preliminary; - Nil; .. Not available.

### TABLE 4. CANADA, CADMIUM PRODUCTION, EXPORTS AND DOMESTIC SHIPMENTS, 1970, 1975 AND 1979-84

| | Production | | Exports | Producers' |
|---|---|---|---|---|
| | All Forms[1] | Refined[2] | Cadmium Metal | Domestic Shipments |
| | (kilograms) | | | |
| 1970 | 1 954 055 | 836 745 | 702 630 | 157 307 |
| 1975 | 1 191 674 | 1 142 508 | 637 797 | 98 820 |
| 1979 | 1 209 459 | 1 454 954 | 1 292 515 | 120 926 |
| 1980 | 1 033 000 | 1 302 955 | 1 095 825 | 88 232 |
| 1981 | 833 788 | 1 293 265 | 1 452 904 | 131 175 |
| 1982 | 886 055 | 1 162 390 | 769 530 | 84 910 |
| 1983 | 1 107 000 | 1 296 078 | 1 365 111 | 91 310 |
| 1984[e] | 1 200 000 | 1 500 000 | 1 400 000 | 120 000 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Production of refined cadmium from domestic ores plus recoverable cadmium content of ores and concentrates exported. [2] Refined metal from all sources and cadmium sponge.

[e] Estimated.

### TABLE 5. CADMIUM METAL PRICES, 1983, 1984

| | Average Monthly Prices | | | |
|---|---|---|---|---|
| | Metals Week | | Metal Bulletin | |
| Month | U.S. Producer | New York Dealer | European Sticks free market | Cominco |
| 1983 | ($US/lb) | | ($US/lb) | ($Cdn/lb) |
| January | 1.000 | 0.700 | 0.561-0.669 | 1.15 |
| February | 1.000 | 0.813 | 0.840-0.943 | 1.15 |
| March | 1.000 | 0.850 | 0.910-1.000 | 1.15 |
| April | 1.000 | 0.850 | 0.923-1.000 | 1.15 |
| May | 1.086 | 0.810 | 0.900-0.970 | 1.15 |
| June | 1.150 | 0.800 | 0.865-0.930 | 1.15 |
| July | 1.150 | 0.800 | 0.840-0.904 | 1.15 |
| August | 1.159 | 0.824 | 0.871-0.925 | 1.15 |
| September | 1.250 | 0.885 | 0.912-0.950 | 1.18 |
| October | 1.250 | 0.852 | 0.814-0.904 | 1.25 |
| November | 1.250 | 0.770 | 0.747-0.792 | 1.25 |
| December | 1.250 | 0.878 | 0.871-0.913 | 1.25 |
| Average | 1.129 | 0.819 | 0.840-0.900 | 1.10 |
| 1984 | | | | |
| January | 1.25 | 0.910 | 0.86-0.90 | 1.25 |
| February | 1.25 | 1.056 | 1.05-1.13 | 1.25 |
| March | 1.50 | 1.320 | 1.45-1.56 | 1.67 |
| April | 2.25 | 1.705 | 1.68-1.74 | 1.75 |
| May | 2.25 | 1.687 | 1.61-1.67 | 2.13 |
| June | 2.25 | 1.543 | 1.51-1.60 | 2.25 |
| July | 1.82 | 1.326 | 1.25-1.35 | 2.25 |
| August | 1.55 | 1.285 | 1.27-1.33 | 1.78 |
| September | 1.55 | 1.324 | 1.29-1.34 | 1.75 |
| October | 1.55 | 1.204 | | 1.75 |
| November | | | | |
| December | | | | |
| Average | | | | |

Sources: Metals Week, Cominco Ltd., Metal Bulletin

## TABLE 6. WESTERN WORLD CADMIUM METAL PRODUCTION, 1981-83

| Continent and Country | 1981 | 1982 | 1983 |
|---|---|---|---|
| | | (tonnes) | |
| **Europe** | | | |
| Austria | 55 | 49 | 46 |
| Belgium | 1 176 | 1 001 | 1 217 |
| Finland | 621 | 566 | 616 |
| France | 664 | 580 | 447 |
| Germany, F.R. | 1 192 | 1 030 | 1 094 |
| Italy | 489 | 475 | 386 |
| Netherlands | 518 | 497 | 513 |
| Norway | 117 | 102 | 117 |
| Spain | 303 | 286 | 278 |
| United Kingdom | 278 | 354 | 340 |
| Yugoslavia | 208 | 174 | 48 |
| **Africa** | | | |
| Algeria | 30 | 30 | 30 |
| Namibia | - | 110 | 51 |
| Zaire | 230 | 281 | 308 |
| **Asia** | | | |
| India | 113 | 131 | 131 |
| Japan | 1 977 | 2 021 | 2 215 |
| Republic of Korea | 300 | 320 | 460 |
| Turkey | 10 | 10 | 10 |
| **America** | | | |
| Canada | 1 293 | 1 162 | 1 296 |
| Mexico | 633 | 674 | 847 |
| Peru | 312 | 425 | 443 |
| United States | 1 871 | 1 351 | 1 382 |
| Other America | 28 | 94 | 210 |
| Australia | 1 031 | 1 010 | 1 104 |
| Other | - | - | - |
| Western World | 13 449 | 12 733 | 13 589 |

Sources: World Metal Statistics, September 1984
Energy Mines and Resources Canada.
- Nil.

# Cement

D.H. STONEHOUSE

## SUMMARY 1983-1984

In 1983, for the fourth consecutive year, cement shipments from Canadian plants were down from the year previous. A slight recovery in 1984 can be credited for the most part to increased exports. Canadian consumption of portland cement bears direct relation to activity in the construction industry. With Canadian construction being anything but buoyant over the past three years, domestic cement consumption has shown no appreciable growth. The lack of mega projects, particularly in western Canada, has steadily reduced demand from that region while demand from eastern Canada has remained fairly steady, assisted in some measure by increased housing activity in 1983. Poor overall construction performance has brought about some rationalization within the Canadian cement industry. A few plants were closed for extended periods during 1983 and again through 1984, a number of kilns were shut down and in general the industry operated at about 50 per cent of rated clinker-producing capacity. One plant (Ciment Québec Inc.) brought on new capacity late in 1982 to bring Canadian total production capacity to 16.54 million tonnes (t).

Exports of Canadian cement and clinker are mainly to the United States, in particular to the states of New York and Michigan. An economic recovery, begun in late 1982 in the United States, created strong demand for many construction materials. Canadian cement production efficiencies and the strong American dollar combine to make Canadian cement and clinker competitive in bordering states, quite different than being imported as a supplement to United States production. Imports from Mexico and from off-continent sources have added to the concerns of the United States cement producers. Protectionist measures have been considered. Of particular concern to Canadian exporters is the Buy America provision within the United States Surface Transportation Assistance Act, 1982 (STAA). STAA provides substantial funding for highway and bridge projects in the United States, representing about 6 per cent total United States cement consumption. Through 1983 and early-1984, Canadian exporters were effectively excluded from supplying these projects by Buy America restrictions on foreign cement. Congress lifted these restrictions in March, 1984 and Canadian cement now enjoys full access to STAA-funded projects. The United States cement industry, however, continues to lobby Congress to restore Buy American restrictions on foreign cement. Legislation to this effect failed to win approval in the last Congress, but will likely be re-proposed during 1985.

The major exporters continued to strengthen their United States base during 1983 and 1984. With the acquisition of General Portland Inc. of Dallas, Texas in 1982, Canada Cement Lafarge Ltd. became the largest cement producer in North America with an annual capacity of 11.663 million t. Early in 1983 a corporate reorganization established Dallas-based Lafarge Corporation which wholly-owns both Canada Cement Lafarge Ltd. and General Portland Inc. The move was designed to give the corporation access to the United States money market and to maintain the overall 52 per cent control of both companies by Lafarge Coppée of Paris, France. Late in 1984 General Portland announced it would temporarily close its 600 000 tpy Miami, Florida plant and would replace production with cement imported from Mexico to supplement production from its Tampa plant and from other sources.

St. Lawrence Cement Inc., through its United States subsidiary, Independent Cement Corp., has acquired or built a cement distribution system in northeastern United States over the past three years. Early in 1984 the company purchased the Catskill, New York cement plant and termi-

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nals from Lone Star Industries Inc. for a reported $US 30 million.

St. Marys Cement Company has two United States affiliates - St. Marys Wyandotte Cement Inc. and St. Marys Wisconsin Cement Inc. The former operates a 300 000 tpy grinding plant near Detroit, the latter a 150 000 tpy grinding plant in Milwaukee and distribution terminals in Green Bay, Wisconsin and Waukegan, Illinois.

## CANADIAN DEVELOPMENTS

The Canadian cement industry is strongly regionalized on the basis of market availability. Capacity is concentrated near growth areas and, fortunately for some, these areas are convenient to foreign market access as well. Some plants were located to take advantage of existing United States markets and to be in a position to utilize waterborne, high-bulk transportation facilities. A typical feature of the Canadian cement industry is its diversification and vertical integration into related construction and construction materials fields. Many cement manufacturers also supply ready-mix concrete, stone, aggregates and concrete products such as slabs, bricks and prestressed concrete units.

Cement manufacture is energy-intensive. It is obvious that research should be concentrated in this area, and specifically within the pyroprocessing sector where over 80 per cent of the energy is consumed. Raw material grinding and finish grinding are being studied to determine optimum particle size for energy consumed.

Energy conservation programs adopted by the Canadian cement industry more than reached the goal of a 9 to 12 per cent reduction in energy consumption per unit of production, based on 1974 calculations. In 1983 the average plant consumption of energy of all types was 4 896 mega joules a tonne, a 21.3 per cent fuel saving over 1974.

A change in the fuel mix from 1974 to 1983 is noted. In 1974 natural gas accounted for 49.5 per cent, petroleum products 39.7 per cent and coal and coke 10.8 per cent. For 1983 natural gas usage was 36.0 per cent of the total energy requirements while petroleum products were 12.3 per cent and coal and coke rose to 51.7 per cent.

The dry process now accounts for over 70 per cent of Canadian portland cement capacity. In 1983 over 80 per cent of production was from dry process plants.

Energy conservation demonstration projects have been funded through the Conservation and Non-Petroleum Sector of Energy, Mines and Resources. The industry is represented on the Industrial Minerals Task Force on Energy Conservation and continues to play an active role in this voluntary organization.

In terms of the energy required to make concrete components and to build concrete structures, along with energy requirements to service and maintain them, they are not so energy-intensive as the nearly 5 giga joules required per t of cement would at first indicate. Through the Canada Centre for Mineral and Energy Technology, a branch of Energy, Mines and Resources and through the Building Research Division of the National Research Council a continuing program of concrete research is managed. Concrete research has generally been confined to strength determination, durability, placement and curing. Currently, great emphasis is being placed on researching the use of super-plasticizers in concrete. Super-plasticizers, a group of admixtures described chemically as naphthalene or melanine sulphonate polymers, have been found to provide greater workability over short time spans or to provide high strength by permitting lower water-cement ratios.

Portland cement used in Canada should conform to the specifications of CAN 3-A5-M83, published by the Canadian Standards Association (CSA). This standard covers the five main types of portland cement. Masonry cement produced in Canada should conform to the CAN 3-A8-M83. Blended hydraulic cements are covered by CAN 3-A362-M83. The cement types manufactured in Canada, but not covered by the CSA standards, generally meet the appropriate specifications of the American Society for Testing and Materials (ASTM).

The three plants in the **Atlantic region** constitute just over 5 per cent of total clinker producing capacity. All three obtain raw materials at or near the plant site. North Star Cement Limited purchases gypsum from Flintkote Holdings Limited, which quarries at Flat Bay about 65 km south of Corner Brook while National Gypsum (Canada) Ltd. supplies the Brookfield plant of Canada Cement Lafarge Ltd. (CCL) from its Milford, Nova Scotia quarry. CCL's New

Brunswick plant was closed during 1983 and 1984 for extensive periods. This plant has been the company's principal source of oil well cement. The region consumed 391 700 t of cement in 1983 according to Canadian Portland Cement Association data.

In the **Quebec region** the five clinker-producing plants have 25 per cent of the Canadian total in an area that has 26.1 per cent of Canadian population and which, in 1983, consumed about 1.2 million t of portland cement or 20 per cent of total consumption. At its St. Constant plant, south of Montreal, CCL experimented with the use of waste tires and rubber as an alternate fuel, as part of a program administered by the federal departments of Environment and Energy, Mines and Resources.

Miron Inc. continued a program to utilize methane gas from a garbage disposal project on its property with the goal of eventually securing as much as 40 per cent of its fuel requirements from this source. The plant's boiler room was operated in 1983 on methane gas. Input garbage has the energy potential to operate the company's two kilns. St. Lawrence Cement Inc. also continued its energy-saving programs during 1983-84 but concentrated its expenditures on downstream integrated operations in the ready mix concrete field and in acquiring distribution facilities in the United States through its subsidiary, Independent Cement Corporation headquartered in Albany, New York. Ciment Québec Inc. began full operation of its new suspension-preheater-precalciner system in 1983, adding about 735 000 tpy to capacity.

Portland cement consumption increased in the **Ontario region** where 40 per cent of the nation's clinker-producing capacity is concentrated. Canada Cement Lafarge Ltd. has brought into production about 3 million t of new cement capacity over the past seven years and currently over half of its operating kilns are less than 10 years old. The limestone for CCL's Bath, Ontario plant is quarried on-site while silica is supplied from Potsdam sandstone at Pittsburgh about 65 km east of Bath and iron oxide is purchased from Hamilton. Gypsum is from Nova Scotia. The Woodstock plant has experimented with the use of selected, processed garbage as fuel. The plant obtains limestone on site, silica from Indusmin Limited, iron oxide from Stelco Inc. and gypsum from southern Ontario mines.

At Picton, Lake Ontario Cement Limited operates one of the largest cement plants in North America. The four-kiln plant supplies cement and clinker to its United States subsidiaries - Rochester Portland Cement Corp. in New York state and Aetna Cement Corporation in Michigan - and cement to its Ontario markets.

At its Mississauga plant, St. Lawrence Cement Inc. has continued to research energy saving techniques. The company obtains limestone from Ogden Point, 160 km east of Toronto on the shore of Lake Ontario and gypsum is purchased from Nova Scotia or from southern Ontario mines.

The Bowmanville plant of St. Marys Cement Limited was expanded in 1973 with the addition of a second kiln. With the acquisition of Wyandotte Cement Inc., the company began shipments of clinker through a newly constructed lakefront loading facility at Bowmanville. The original plant at St. Marys, constructed in 1912 to serve the Toronto area, has been expanded and modernized over the years, most recently with the installation of a 680 000 tpy kiln and four-stage suspension preheater.

Federal White Cement's plant at Woodstock, can produce up to 100 000 tpy of white cement.

Two companies, Canada Cement Lafarge Ltd. and Genstar Cement Limited operate a total of five clinker producing plants in the **Prairie region** and three in the **Pacific region** along with two clinker grinding plants. This **Western region** has 30 per cent of clinker producing capacity, including the recently completed expansion at Genstar's Edmonton, Alberta plant. Consumption of portland cement in the western provinces accounted for 38 per cent of Canadian total. Recent expansions at Edmonton and at Exshaw increased capacity by about 1.3 million tpy through 1981.

Genstar Cement Limited continued to increase the productive capacity at its Cadomin limestone property which supplies the Edmonton plant through a 4 500 t unit train and materials handling system. A limestone quarry at Mafeking, Manitoba, near the Manitoba-Saskatchewan border, supplies limestone to Genstar's Regina plant, while the Winnipeg plant is supplied from Steep Rock, Manitoba.

CCL's Winnipeg plant obtains limestone from the company's quarry at Steep Rock on

Lake Manitoba, gypsum from Westroc Industries Limited at Amaranth, silica from Beausejour and clay adjacent to the plant site at Fort Whyte. Raw material for the Exshaw plant is mainly from the plant site but for gypsum from Westroc and iron oxide from Cominco Ltd. Limestone from Texada Island supplies the company's Vancouver plant at Richmond. Their Kamloops plant is supplied from resources close to the plant site.

## WORLD DEVELOPMENTS

Cement markets are regional and centred in developing urban areas where construction activity is concentrated, or in areas where mining or heavy engineering construction projects are being carried out. The normal market area of a given cement-producing plant depends on the amount of transportation cost that the selling price can absorb. A potential large volume of sales could warrant a secondary distribution terminal; water transportation to a distribution system could extend a plant's market area even farther. Because raw materials for cement manufacture are generally widespread, most countries can supply their own cement requirements if the market volume warrants a plant. Few countries rely entirely on imports for their cement needs. However, some countries rely heavily on export markets for their surplus cement production in order to operate facilities economically.

Specialty cements such as white cement can be transported greater distances than ordinary grey portland cement because the transportation costs do not represent as high a proportion of the landed price, and because quantities required are generally much smaller than for portland cement.

Cement shortages in countries experiencing a buoyant surge in construction have led to exceptions to the norm and resulted in cement being shipped unusual distances.

The state of the portland cement industry in the United States, and a surprisingly large demand for cement in construction, particularly in the west and mid-west, created improved export opportunities for Canadian portland cement during the late 1970s, peaking in 1979.

Significant quantities of portland cement were imported into the United States from such countries as Australia, Columbia, Denmark, France, Korea, Mexico, Norway, Spain and Venezuela as well as from Canada.

Cembureau, The European Cement Association, has published Cement Standards of the World - Portland Cement and its Derivatives, in which standards are compared. Cembureau's World Cement Directory lists production capacities by country and by company.

## USES

Portland cement is produced by burning, usually in a rotary kiln, an accurately proportioned, finely ground mixture of limestone, silica, alumina and iron oxide. The three basic types of portland cement, Normal Portland, High-Early-Strength Portland, and Sulphate-Resisting Portland, are produced by most Canadian cement manufacturers.

Cement has little use alone but, when combined with water, sand, gravel, crushed stone or other aggregates in proper proportions acts as a binder, cementing the materials together as concrete. Concrete has become a widely used and readily adaptable building material which can be poured on site in large engineering projects, or used in the form of delicate precast panels or heavy, prestressed columns and beams in building construction.

Kiln discharge, in the shape of rough spheres, is a fused, chemically complex mixture of calcium silicates and aluminates termed clinker, which is mixed with gypsum (4 to 5 per cent by weight) and ground to a fine powder to form portland cement. By close control of the raw mix, the burning conditions and of the use of additives in the clinker-grinding procedure, finished cements displaying various desirable properties can be produced.

Moderate Portland Cement and Low-Heat-of-Hydration Portland Cement, designed for use in concrete to be poured in large masses, such as in dam construction, are manufactured by several companies in Canada. Masonry cement (generic name) includes such proprietary names as Mortar Cement, Mortar Mix (unsanded), Mason's Cement, Brick Cement and Masonry Cement. The latter product produced by portland cement manufacturers, is a mixture of portland cement, finely ground high-calcium limestone (35 to 65 per cent by weight) and a plasticizer. The other products do not necessarily consist of portland cement and limestone, and may include a mixture of portland cement and hydrated lime and/or other plasticizers.

## OUTLOOK

The mining industries which supply the materials of construction fared no better during 1983 and 1984 than did either the construction industry or the mining industry in general. Total plant shutdowns of unprecedented extent were not uncommon in the cement industry.

The Canadian Construction Association predicts that near-term growth in construction will be less than the average growth in the economy with non-residential building and heavy construction activity being above average but offset by no growth in residential building and engineering work. The medium- and long-term outlook is for average growth as engineering projects pick up, non-residential building activity remains steady and the residential building sector continues to show little if any growth. The capital investment intentions for 1984 of major Canadian companies surveyed during 1984 were increased from 1983 intentions in both the manufacturing and non-manufacturing sectors. Statistics Canada's review of private and public investment in Canada has been adjusted to indicate capital and repair expenditures on construction in 1983 of $56.0 billion, about the same as in 1982, while 1984 expenditures rose to $56.9 billion.

A healthy economy would permit the construction industry and that portion of the mining industry which depends on it to plan five to ten years ahead with obvious benefits in efficiency, rather than to invest with short-term survival as the main incentive.

The cement industry in Canada is capable of meeting immediate demands and is also capable of expansion to meet even greater demand from domestic and foreign markets should opportunities be presented. The pattern of consumption of portland cement established during 1983-84 will likely persist for a few years or until the development of mega projects once again alters the current demand for cement.

Conservation of energy and raw materials within the cement industry is of worldwide concern and provides a theme around which major developments in the industry have taken place. Of particular note is the emphasis on blended cements and the utilization of slag, ash and other byproducts. Even greater additions to production capacities than those witnessed during the past few years will be needed to meet demand in many developing countries.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (cents per hundred pounds) | | |
| CANADA | | | | | |
| 29000-1 | Portland and other hydraulic cement, nop; cement clinker | free | free | 6 | free |
| 29005-1 | White, nonstaining Portland cement | 3.9 | 3.9 | 8 | 2 2/3 |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | (cents per hundred pounds) | | | | |
| 29005-1 | 3.9 | 3.8 | 3.8 | 3.7 | 3.7 |

UNITED STATES (MFN)

| | | |
|---|---|---|
| 511.11 | White, nonstaining Portland cement per 100 pounds including weight of container | 1¢ |
| 511.14 | Other cement and cement clinker | free |
| 511.21 | Hydraulic cement concrete | free |

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | (% ad valorem) | | | | |
| 511.25 | Other concrete mixed, per cubic yard | 6.2 | 5.9 | 5.6 | 5.2 | 4.9 |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated 1983, USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, CEMENT PRODUCTION AND TRADE, 1982-84

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Production**[1] | | | | | | |
| By province | | | | | | |
| Ontario | 2 800 000 | 215,208 | 2 90[illegible] 565 | 203,243 | 3 100 000 | 222,859 |
| Quebec | 2 307 000 | 129,987 | 2 170 977 | 127,567 | 2 675 000 | 146,634 |
| Alberta | 1 468 000 | 112,830 | 1 189 610 | 126,860 | 1 025 000 | 116,450 |
| British Columbia | 776 000 | 70,352 | 76 570 | 66,282 | 810 000 | 84,297 |
| Nova Scotia | .. | 27,670 | .. | 10,014 | .. | 17,084 |
| Manitoba | 275 000 | 21,137 | 289 672 | 31,983 | 365 000 | 42,891 |
| Saskatchewan | 206 000 | 15,833 | 184 268 | 21,154 | 165 000 | 17,766 |
| New Brunswick | .. | 13,066 | .. | 8,965 | .. | 9,676 |
| Newfoundland | .. | 6,443 | .. | 10,035 | .. | 9,453 |
| Total | 8 418 000 | 612,536 | 7 870 878 | 606,101 | 8 618 000 | 667,110 |
| By type | | | | | | |
| Portland | 8 152 000 | .. | 7 614 832 | .. | 8 334 600 | .. |
| Masonry[2] | 266 000 | .. | 256 046 | .. | 284 000 | .. |
| Total | 8 418 000 | 612,526 | 7 870 878 | 606,101 | 8 618 600 | 667,110 |
| **Exports** | | | | | (Jan.-Sept. 1984) | |
| Portland cement | | | | | | |
| United States | 1 464 650 | 66,829 | 1 499 751 | 71,574 | 1 476 123 | 73,530 |
| Saudi Arabia | 285 339 | 12,446 | 40 093 | 1,735 | - | - |
| Algeria | - | - | 19 076 | 1,112 | 1 510 | 290 |
| Other countries | 2 152 | 248 | 2 161 | 286 | 5 641 | 534 |
| Total | 1 752 141 | 79,523 | 1 561 081 | 74,707 | 1 483 274 | 74,354 |
| Cement and concrete basic products | | | | | | |
| United States | .. | 30,103 | .. | 44,443 | .. | 42,797 |
| Other countries | .. | 1,870 | .. | 1,935 | .. | 1,664 |
| Total | .. | 31,973 | .. | 46,378 | .. | 44,461 |
| **Imports** | | | | | | |
| Portland cement, standard | | | | | | |
| United States | 469 643 | 32,508 | 227 251 | 16,119 | 194 414 | 12,539 |
| United Kingdom | - | - | 170 | 14 | 170 | 14 |
| Total | 469 643 | 32,508 | 227 421 | 16,132 | 194 584 | 12,553 |
| White cement | | | | | | |
| United States | 4 716 | 386 | 1 457 | 230 | 1 279 | 206 |
| Japan | 477 | 83 | 1 167 | 187 | 1 079 | 172 |
| Other | 50 | 6 | 249 | 31 | 153 | 19 |
| Total | 5 243 | 475 | 2 873 | 458 | 2 511 | 396 |
| Aluminous cement | | | | | | |
| United States | 14 251 | 2,833 | 3 338 | 1,173 | 2 518 | 882 |
| South Africa | 8 | 11 | | | | |
| Total | 14 259 | 2,844 | 3 338 | 1,173 | 2 518 | 882 |

**TABLE 1.** (cont'd)

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes)<br>(Jan-Sept 1984) | ($000) |
| Cement, nes | | | | | | |
| United States | 35 291 | 4,797 | 19 069 | 2,776 | 15 070 | 2 213 |
| Japan | 250 | 44 | 200 | 33 | 100 | 17 |
| United Kingdom | 67 | 9 | 32 | 11 | 8 | 5 |
| West Germany | 30 | 4 | 7 | 1 | 7 | 1 |
| France | 14 | 2 | - | - | - | - |
| Italy | 6 | 1 | 13 | 3 | 9 | 2 |
| Switzerland | - | 65 | 4 | 1 | | |
| Other | - | - | 5 | 9 | - | - |
| Total | 35 658 | 4,857 | 19 330 | 2,835 | | |
| Total cement imports | 231 614 | 131,594 | 252 962 | 20,598 | 15 194 | 2 238 |
| | | | | | | |
| Refractory cement and mortars | | | | | | |
| United States | .. | 12,308 | .. | 13,374 | .. | 9,747 |
| Ireland | .. | 625 | .. | 503 | .. | 503 |
| Austria | .. | 157 | .. | 203 | .. | 203 |
| West Germany | .. | 88 | .. | 239 | .. | 220 |
| United Kingdom | .. | 21 | .. | 111 | .. | 43 |
| Other countries | .. | 65 | .. | 26 | .. | 22 |
| Total | .. | 13,264 | .. | 14,456 | .. | 10,740 |
| | | | | | | |
| Cement and concrete basic products, nes | | | | | | |
| United States | .. | 2,712 | .. | 3,969 | .. | 3,141 |
| Japan | .. | 64 | - | - | - | - |
| Austria | .. | 11 | - | - | - | - |
| France | .. | 3 | .. | 1 | - | - |
| United Kingdom | .. | 2 | .. | 1 | - | - |
| Other countries | .. | 9 | .. | 30 | .. | 29 |
| Total | .. | 2,801 | .. | 4,001 | .. | 3,171 |
| | | | | | | |
| Cement clinker | | | | | | |
| United Kingdom | 180 | 63 | - | - | - | - |
| United States | 36 | 29 | 53 | 2 | 53 | 2 |
| Japan | - | - | - | - | - | - |
| Total | 216 | 92 | 53 | 2 | 53 | 2 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments plus quantities used by producers. [2] Includes small amounts of other cement.

P Preliminary; .. Not available; - Nil; nes Not elsewhere specified.

## TABLE 2. CEMENT PLANTS, APPROXIMATE ANNUAL GRINDING CAPACITY, END OF 1984

| Company | Plant | Wet, Dry, Pre-heater | Fuel (Coal Oil Gas) | No. of Kilns | Grinding Capcity | Clinker Capacity |
|---|---|---|---|---|---|---|
| | | | | | (000 tpy) | |
| **Atlantic** | | | | | | |
| Canada Cement Lafarge Ltd. | Brookfield, N.S. | D | C,O | 2 | 485 | 458 |
| | Havelock, N.B. | D | C,O | 2 | 315 | 300 |
| North Star Cement Limited | Corner Brook, Nfld. | Dx | O | 1 | 250 | 120 |
| Atlantic Region Total | | | | 5 | 1 050 | 878 |
| **Quebec** | | | | | | |
| Canada Cement Lafarge Ltd. | St. Constant | D | O,G | 2 | 955 | 902 |
| Ciment Québec Inc. | St. Basile | W,Dc | O | 3 | 575 | 1 106 |
| Miron Inc. | Montreal | D | O,G | 2 | 1 000 | 840 |
| St. Lawrence Cement Inc. | Beauport | W | C,O | 2 | 550 | 598 |
| (Independent Cement Inc.) | Joliette | D | C,O | 4 | 1 000 | 976 |
| Quebec Region Total | | | | 13 | 4 080 | 4 422 |
| **Ontario** | | | | | | |
| Canada Cement Lafarge Ltd. | Woodstock | W | C,G | 2 | 535 | 505 |
| | Bath | Dx | O,G | 1 | 1 000 | 943 |
| Federal White Cement | Woodstock | D | O | 1 | 100 | 100 |
| Lake Ontario Cement Limited | Picton | D,Dx | C,G | 4 | 744 | 1 419 |
| St. Lawrence Cement Inc. | Clarkson | W,Dc | C,O,G | 3 | 2 400 | 1 700 |
| St. Marys Cement Limited | Bowmanville | W | C | 2 | 790 | 600 |
| | St. Marys | W,Dx | O,G | 3 | 800 | 990 |
| Ontario Region Total | | | | 16 | 6 270 | 6 257 |
| **Prairies** | | | | | | |
| Canada Cement Lafarge Ltd. | Fort Whyte, Man. | W | O,G | 2 | 565 | 532 |
| | Exshaw, Alta. | D,Dc | G | 3 | 1 230 | 1 184 |
| | Edmonton, Alta. | | | | 220 | |
| Genstar Cement Limited | Winnipeg, Man. | W | O,G | 1 | 325 | 310 |
| | Regina, Sask. | D | O,C | 1 | 375 | 214 |
| | Edmonton, Alta. | W,Dc | G | 4 | 2 040 | 1 186 |
| Prairies Region Total | | | | 11 | 4 755 | 3 426 |
| **British Columbia** | | | | | | |
| Canada Cement Lafarge Ltd. | Kamloops | D | G | 1 | 190 | 180 |
| | Richmond | W | O,G | 2 | 555 | 522 |
| Genstar Cement Limited | Tilbury Island | Dx | O,G | 1 | 1 000 | 855 |
| B.C. Region Total | | | | 4 | 1 745 | 1 557 |
| CANADA TOTAL (9 companies) | | | | 49 | 17 900 | 16 540 |

Source: Market and Economic Research Department, Portland Cement Association.

## TABLE 3. CANADA, CEMENT PLANTS, KILNS AND CAPACITY UTILIZATION, 1977-84

| | Clinker Producing Plants | Kilns | Approximate Cement Grinding Capacity[1] | Portland and Masonry Cement Production[2] | Clinker Exports[3] | Approximate Total Production[4] | Capacity Utilization |
|---|---|---|---|---|---|---|---|
| | | | (tpy) | (t) | (t) | (t) | (%) |
| 1977 | 22 | 49 | 14 885 000 | 9 639 679 | 775 145 | 10 414 824 | 72 |
| 1978 | 24 | 51 | 15 985 000 | 10 558 279 | 1 077 274 | 11 635 553 | 72 |
| 1979 | 24 | 51 | 15 985 000 | 11 765 248 | 1 530 537 | 13 295 785 | 83 |
| 1980 | 23 | 47 | 16 363 000 | 10 274 000 | 726 087 | 11 000 087 | 67 |
| 1981 | 23 | 48 | 16 771 000 | 10 145 000 | 524 006 | 10 669 006 | 64 |
| 1982 | 23 | 48 | 16 771 000 | 8 418 000 | 290 329 | 8 708 329 | 50 |
| 1983 | 23 | 49 | 17 900 000 | 7 870 878 | 404 793 | 8 275 671 | 46 |
| 1984 | 23 | 49 | 17 900 000 | 8 618 600 | 350 000$^{e}$ | 8 968 600$^{e}$ | 50 |

Sources: Statistics Canada, U.S. Bureau of Mines, Portland Cement Association (PCA)

[1] Includes two plants that grind only. [2] Producers' shipments and amounts used by producers. [3] Imports to United States from Canada. [4] Cement shipments plus clinker exports.

$^{e}$ Estimated.

## TABLE 4. CANADA, HOUSE CONSTRUCTION, BY PROVINCE, 1982 AND 1983

| | Starts | | | Completions | | | Under Construction | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1982 | 1983 | % Diff. | 1982 | 1983 | % Diff. | 1982 | 1983 | % Diff. |
| Newfoundland | 2 793 | 3 281 | 17.4 | 2 331 | 3 176 | 36.2 | 3 373 | 3 494 | 3.5 |
| Prince Edward Island | 248 | 673 | 171.3 | 98 | 548 | 459.1 | 196 | 316 | 61.2 |
| Nova Scotia | 3 691 | 5 697 | 54.3 | 3 174 | 5 069 | 59.7 | 2 506 | 2 984 | 19.0 |
| New Brunswick | 1 680 | 4 742 | 182.2 | 1 427 | 3 487 | 144.3 | 1 122 | 2 346 | 109.0 |
| Total (Atlantic Provinces) | 8 412 | 14 393 | 71.1 | 7 030 | 12 280 | 74.6 | 7 197 | 9 140 | 26.9 |
| Quebec | 23 492 | 40 318 | 71.6 | 21 526 | 35 681 | 65.7 | 14 164 | 18 320 | 29.3 |
| Ontario | 38 508 | 54 939 | 42.6 | 40 437 | 55 287 | 36.7 | 31 009 | 30 243 | -2.4 |
| Manitoba | 2 030 | 5 985 | 194.8 | 1 633 | 4 076 | 149.6 | 1 149 | 3 048 | 165.2 |
| Saskatchewan | 6 822 | 7 269 | 6.5 | 5 666 | 8 090 | 42.7 | 4 583 | 3 667 | 19.9 |
| Alberta | 26 789 | 17 134 | 36.0 | 31 364 | 24 693 | 21.2 | 17 663 | 8 336 | 52.8 |
| Total (Prairie Provinces) | 35 641 | 30 388 | -14.7 | 38 663 | 36 859 | -4.8 | 23 395 | 15 051 | -35.6 |
| British Columbia | 19 807 | 22 607 | 14.1 | 26 286 | 22 901 | -12.8 | 13 290 | 12 176 | -8.3 |
| Total Canada | 125 860 | 162 645 | 29.2 | 133 942 | 163 008 | 21.7 | 89 055 | 84 930 | -4.6 |

Source: Canada Mortgage and Housing Corporation.

### TABLE 5. CANADA, VALUE OF CONSTRUCTION[1] BY TYPE, 1982-84

| | 1982 | 1983 | 1984 |
|---|---|---|---|
| | | ($ millions) | |
| **Building Construction** | | | |
| Residential | 13,581 | 16,683 | 17,240 |
| Industrial | 3,044 | 2,502 | 2,739 |
| Commercial | 7,064 | 6,228 | 5,817 |
| Institutional | 3,092 | 3,198 | 3,183 |
| Other building | 2,062 | 1,989 | 2,139 |
| Total | 28,843 | 30,600 | 31,118 |
| **Engineering Construction** | | | |
| Marine | 480 | 404 | 414 |
| Highways, airport runways | 4,310 | 4,270 | 4,328 |
| Waterworks, sewage systems | 2,244 | 2,402 | 2,391 |
| Dams, irrigation | 314 | 295 | 306 |
| Electric power | 4,866 | 4,673 | 3,827 |
| Railway, telephones | 2,390 | 2,531 | 2,811 |
| Gas and oil facilities | 9,706 | 8,115 | 9,141 |
| Other engineering | 2,912 | 2,808 | 2,635 |
| Total | 27,222 | 25,498 | 25,853 |
| Total construction | 56,065 | 56,098 | 56,971 |

Source: Statistics Canada.

[1] Actual expenditures 1982, preliminary actual 1983, intentions 1984.

### TABLE 6. CANADA, VALUE OF CONSTRUCTION[1] BY PROVINCE, 1982-84

| | 1982 | | | 1983 | | | 1984 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Building Construction | Engineering Construction | Total | Building Construction | Engineering Construction | Total | Building Construction | Engineering Construction | Total |
| | | | | | ($000) | | | | |
| Newfoundland | 414,429 | 750,073 | 1,164,502 | 496,177 | 920,309 | 1,416,486 | 529,042 | 904,131 | 1,433,173 |
| Nova Scotia | 681,430 | 884,462 | 1,565,892 | 850,097 | 1,113,145 | 1,963,242 | 935,167 | 1,263,679 | 2,198,846 |
| New Brunswick | 619,611 | 462,089 | 1,081,700 | 749,843 | 414,249 | 1,164,092 | 866,945 | 503,785 | 1,370,730 |
| Prince Edward Island | 86,981 | 72,006 | 158,987 | 106,406 | 70,694 | 177,100 | 117,272 | 79,046 | 196,318 |
| Quebec | 5,547,556 | 4,672,040 | 10,219,596 | 6,693,708 | 4,388,346 | 11,082,054 | 7,183,496 | 4,352,134 | 11,535,630 |
| Ontario | 8,897,137 | 5,510,574 | 14,407,711 | 10,015,802 | 4,819,861 | 14,835,663 | 10,498,275 | 5,031,231 | 15,529,506 |
| Manitoba | 764,362 | 657,850 | 1,422,212 | 986,418 | 656,087 | 1,642,505 | 1,083,361 | 698,296 | 1,781,657 |
| Saskatchewan | 1,165,189 | 1,343,933 | 2,509,122 | 1,451,012 | 1,413,370 | 2,864,382 | 1,410,011 | 1,515,541 | 2,925,552 |
| Alberta | 6,053,165 | 8,349,406 | 14,402,571 | 4,761,621 | 7,044,529 | 11,806,150 | 3,920,440 | 7,281,719 | 11,202,159 |
| British Columbia, Yukon and Northwest Territories | 4,613,640 | 4,519,456 | 9,133,096 | 4,488,816 | 4,657,297 | 9,146,113 | 4,574,138 | 4,223,386 | 8,797,524 |
| Canada | 28,843,500 | 27,221,889 | 56,065,389 | 30,599,900 | 25,497,887 | 56,097,787 | 31,118,147 | 25,852,948 | 56,971,095 |

Source: Statistics Canada.

[1] Actual expenditures 1982, preliminary actual 1983, intentions 1984.

# Clays and Clay Products

M. PRUD'HOMME

Clays are a complex group of industrial minerals, each generally characterized by different mineralogy, occurrence and uses. All are natural, earthy, fine-grained minerals of secondary origin, composed mainly of a group of hydrous aluminum phyllosilicates and may contain iron, alkalis and alkaline earths. The clay minerals, formed by the chemical weathering or alteration of aluminous minerals are generally classified into four major groups based on detailed chemistry and crystalline structure - the kaolinite group, the smectite group (montmorillonite group of some usages), the clay-mica group and the chlorite group. Clay deposits suitable for the manufacture of ceramic products may include non-clay minerals such as quartz, calcite, dolomite, feldspar, gypsum, iron-bearing minerals and organic matter. The non-clay minerals may or may not be deleterious, depending upon individual amounts present and on the particular application for which the clay is intended.

The commercial value of clays, and of shales that are similar in composition to clays, depends mainly on their physical properties - plasticity, strength, shrinkage, vitrification range and refractoriness, fired colour, porosity and absorption - as well as proximity to growth centres in which clay products will be consumed.

Brick and drain tile manufacturing included in the heavy clay products category accounts for nearly 80 per cent of the total value of output by clay products manufacturers using material from domestic sources.

## USES, TYPE AND LOCATION OF CANADIAN DEPOSITS

**Common Clays and Shale.** Common clays and shales are the principal raw materials available from Canadian deposits for the manufacture of structural clay products. They are found in all parts of Canada, but deposits having excellent drying and firing properties are generally scarce and new deposits are continually being sought.

The clay minerals in common clays and shales are chiefly illitic or chloritic. The material is sufficiently plastic to permit molding and vitrification at low temperature. Suitable common clays and shales are utilized in the manufacture of heavy clay products such as common brick, facing brick, structural tile, partition tile, conduit tile, quarry tile and drain tile. There are no specific recognized grades of common clay and shale. Specifications are usually based upon the physical and chemical tests of manufactured products. The raw materials utilized in the heavy clay industry usually contain up to 35 per cent quartz. If the quartz, together with other nonplastic materials, exceeds this percentage, the plasticity of the clay is reduced and the quality of the ware is lowered. If calcite or dolomite is present in sufficient quantities, the clay will fire buff and the fired strength and density will be adversely affected.

Most of the surface deposits of common clays in Canada are the result of continental glaciation and subsequent stream transport. Such Pleistocene deposits are of interest to the ceramic industry and include stoneless marine and lake sediments, reworked glacial till, interglacial clays and floodplain clays.

In eastern Canada, shales are consumed in large quantities for manufacturing cement near Corner Brook in western Newfoundland, and at Havelock in King County, New Brunswick. Common clay from glacial drift is used in Ontario as a source of silica and alumina in the local manufacture of grey portland cement at Woodstock and St. Mary's. In Manitoba, shales and clays from glacial Lake Agassiz are extracted to produce lightweight aggregates. In Alberta, local glacial clays from Regina are used for manufacturing cement, lightweight aggregates

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and mineral wood insulation. In British Columbia, altered volcanic ash is extracted at Barnhard Vale for cement, and in Quesnel for use as a natural pozzolan.

The shales provide the best source of raw material for making brick. In particular, those found in Cambrian, Ordovician and Carboniferous rocks in eastern Canada, and Jurassic, Cretaceous and Tertiary rocks in western Canada, are utilized by the ceramic industry.

**China Clay (Kaolin).** China clay is a white clay composed mainly of kaolinitic minerals formed from weathered igneous rocks. Some deposits occur in sedimentary rocks as tabular lenses and discontinuous beds or in rocks that have been hydrothermally altered. Commercial china clays are beneficiated to improve their whiteness when used as fillers and their whitefiring characteristics when used in ceramics. None of the crude kaolins known to exist in Canada have been developed, primarily because of beneficiation problems and the small size of some deposits.

China clay is used primarily as a filler and coating material in the paper industry, a raw material in ceramic products, and a filler in rubber and in other products. In the ceramic industry china clay is used as a refractory raw material. In prepared whiteware bodies such as wall tile, sanitaryware, dinnerware, pottery and electrical porcelain, quantities of nepheline syenite, silica, feldspar and talc are used as well.

Several occurrences of kaolin in Canada have attracted attention. In British Columbia, a deposit of clay similar to a secondary kaolin occurs along the Fraser River near Prince George. In southern Saskatchewan, there is a source of sandy kaolinised clay with off-white coloured fines which would be suitable for filler or coating material if it could be beneficiated adequately. Known deposits occur near Fir Mountain, Flintoft, Knollys and Wood Mountain from which clays in the Lower Whitemud Formation have been analyzed to produce a whiter commercial china clay. In Manitoba, various kaolinitic-rock deposits have been reported at Arborg, on Deer Island (Punk Island) and Black Island in Lake Winnipeg, and in the northwest at Cross Lake and Pine River; the Swan River Formation also has been studied as a potential source of kaolin. In Ontario, extensive deposits of kaolin-silica sand mixtures occur along the Missinaibi and the Mattagami rivers. In 1982, a feasibility study was done to evaluate the use of borehole mining in the Moose River basin, north of Kapuskasing, where silica-kaolin deposits lie under deep overburden. The distance from markets and the difficult terrain and climate still hinder development of these deposits. In Quebec, kaolin deposits have been actively mined in the past as a coproduct of a silica operation, near St-Remi-d'Amherst, in Papineau County. Occurrences near Chateau-Richer in Montmorency County and Pointe Comfort in Gatineau County have been studied as a potential source of kaolin for alumina, suitable for aluminous cement and refractories. Field investigations have been carried out to delineate known occurrences, especially near Thirty-one Mile Lake.

**Ball Clay.** Ball clay is defined as a fine-grained, highly plastic and mainly kaolinitic sedimentary clay. Natural colours range from white to brown, blue, grey and black, usually related to carbonaceous material. Fired colours may be white to offwhite. They are extremely refractory materials and have less alumina and more silica than kaolin. Ball clays occur in beds or lenticular units characterized by complex variation, both vertically and laterally.

Ball clays occurring in Canada are mineralogically similar to high-grade, plastic fire clay and are composed principally of fine-particle kaolinite, quartz and mica. These clays are known to occur in the Whitemud and the Ravenscrag Formations - Willowbunch Member - of southern Saskatchewan. Clay production takes place near Claybank, Eastend, Estevan, Flintoft, Readlyn, Rockglen, Willowbunch and Wood Mountain.

**Fire Clay (Refractory Clay).** Fire clay is a detrital clay mainly composed of kaolinite with a high content of alumina and silica. It usually occurs in sedimentary rocks as lenticular bodies. These clays may range in plasticity from essentially that of ball clay to nonplastic varieties such as flint clay. They are formed by alteration of aluminous sediments deposited in a swampy environment or following transportation and concentration of clayey material.

Fire clay is used in the manufacture of products requiring high resistance to heat such as fire brick, insulating brick and refractory mortar. The refractory suitability is determined by the pyrometric cone equivalent (PCE) test. Canadian fire clays are used principally for the manufacture of medium- and high-duty fire brick and refractory specialties. Known Canadian fire clays are not sufficiently refractory for the manufacture of superduty refractories without the addition of some very refractory material such as alumina.

Various grades of good-quality fire clay occur in the Whitemud Formation in southern Saskatchewan and on Sumas Mountain in British Columbia. Fire clay, associated with lignite as well as with kaolin-silica sand mixtures, occurs in the James Bay watershed of northern Ontario along the Missinaibi, Abitibi, Moose and Mattagami rivers. At Shubenacadie, Nova Scotia, some seams of clay are sufficiently refractory for medium-duty fire clay. Clay from Musquodoboit, Nova Scotia, has been used by some foundries in the Atlantic provinces, and the properties and extent of this clay were investigated by the Nova Scotia Department of Mines. Ontario and Quebec have no producing domestic sources of fire clay and import most of their requirements from the United States.

**Stoneware Clay.** Stoneware clays are intermediary between low-grade common clays and the high-grade kaolinitic clays. They are typically a mixture of kaolinitic clay minerals and micaceous clay minerals. Stoneware clays must be capable of being fully vitrified at a relatively low temperature.

Stoneware clays are used extensively in the manufacture of sewer pipe, flue liners, and facing brick. They are widely used by amateur and studio potters.

The principal source of stoneware clay in Canada is the Whitemud Formation in southern Saskatchewan and southeastern Alberta. Stoneware clays also occur near Abbotsford on Sumas Mountain, at Chimney Creek Bridge, Quesnel and Williams Lake, British Columbia; near Swan River in Manitoba; and in Nova Scotia, at Musquodoboit and at Shubenacadie where it is used principally for manufacture of buff-facing bricks.

**Bentonite and Fuller's Earth.** Bentonite consists primarily of montmorillonite clay, and is formed from volcanic ash, tuff or glass, other igneous rocks, or from rocks of sedimentary origin. Sodium bentonite has strong swelling properties and possesses a high dry-bonding strength. Calcium bentonite of the non-swelling type, exhibits adsorptive characteristics. Fuller's earth contains mainly smectite-group clay minerals and is very similar to non-swelling bentonite. It is formed by alteration of volcanic ash or by direct chemical precipitation of montmorillonite in shallow marine basins. Fuller's earth is characterized by absorptive properties, catalytic action, bonding power and cation-exchange capacities.

**Drilling Mud and Activated Clays.** Drilling mud contains about 10 per cent swelling bentonite. Synthetic bentonites may also be used for special muds. The swelling properties of a bentonite used as a drilling mud may be improved by adding soda ash in a drying process to substitute calcium cations by sodium cations. Activated clays are non-swelling bentonites that are acid leached to remove impurities and to increase reactive surface and bleaching power. They are used for decolouring mineral oils and as catalysts.

Bentonite, Fuller's earth and Activated clays are covered at intervals in a separate mineral review.

## CANADIAN INDUSTRY

**Clays.** Production of clays is captive to its use in lightweight aggregates, cement and mineral wool insulation, which consumed mainly common clay, stoneware clay and ball clay. In Canada, there is no commercial production of china clay, and all requirements are imported mainly from the United States (97 per cent) and the United Kingdom (3 per cent) into Ontario (56 per cent), Quebec (35 per cent), Manitoba (4 per cent) and British Columbia (3 per cent). Demand for china clay depends principally on the paper industry which accounts for more than 75 per cent of its use. The traditional method of shipping kaolin is dry, but transportation as a 70 per cent solid-slurry is increasing. Consumption of china clay has risen in response to certain needs in the refractories industry. It may be used in its natural form, or when calcined, to compete with mullite in some uses. Average prices for imported kaolin have increased at an average annual rate of 6 per cent from 1982 to 1984. The current price is about $125 per t.

Fire clay, with an estimated unit value of $71.20 per t in 1984 is imported for use in refractories from the United States (98 per cent) into Ontario (74 per cent) and Quebec (21 per cent).

**Clay products.** Production of clay products includes structural materials - such as bricks and tiles - sewer pipes, flue linings, drain tiles, earthenwares, tablewares, sanitaryware and pottery. In 1984, nearly 35 companies were producing more than 95 per cent of total output. Production of clay products has risen from $95 million in 1982 to $141 million in 1983, mainly due to increased output in eastern Canada. Imports of structural materials account for only 5 per cent of total clay products and are shipped into Ontario (50 per cent) and British Columbia (40 per cent).

The average import price in 1984 was about $190 per thousand bricks, a small increase from $176 per thousand bricks in 1983.

Imports of ceramic tiles account for 25 per cent of the value of imported manufactured clay products. Sources are Italy (47 per cent), Spain (17 per cent) and Japan (15 per cent) into Ontario (55 per cent), Quebec (25 per cent) and British Columbia (16 per cent). Imports of tablewares account for about 45 per cent of the value of manufactured clay products. Sources are United Kingdom (36 per cent) and Japan (27 per cent).

Toronto Brick Co. closed its brick plant near Toronto in the Fall of 1984. In Quebec, La Compagnie 124984 Canada has been reactivating the former Québrique brick plant near Westbury to produce facing bricks. Also, La brique Citadelle, in Beauport, has carried out a modernization program since 1983 to upgrade handling outlet and improve productivity. Blue Mountain Pottery Ltd. of Collingwood, Ontario, is diversifying into the field of hi-tech ceramics relating to computers and communication equipment. Expertise of the Ontario Research Foundation is being utilized. Since 1983, the federal department of Energy, Mines and Resources has conducted a potential opportunity study for industrial minerals used in the ceramic sector, including abrasives, glass, clay products and refractories. With the cooperation of 60 major Canadian manufacturers, more than 50 industrial minerals were surveyed in terms of consumption, source of supply and specifications.

**Refractories.** Refractories are produced in Canada by 16 major manufacturers of basic and alumina-silica products. Special refractories such as refractory mineral wool and carbon-compound mortars are also produced. These products are imported mainly from the United States (98 per cent) and include alumina bricks into Ontario (98 per cent) and magnesite bricks into Ontario (83 per cent), Quebec (10 per cent), Nova Scotia (5 per cent) and British Columbia (5 per cent). Trade in refractories since 1982 has increased sharply. Imports increased at an average annual rate of 28 per cent and exports increased 30 per cent. Refractories account for 78 per cent of total exports of all products, mainly to American markets (96 per cent).

## WORLD REVIEW

World production of kaolin in 1983 was around 20 million t, an increase of 5 per cent from 1982. Major world producers are the United States (32 per cent), the United Kingdom (15 per cent) and the U.S.S.R. (15 per cent). Ball clay production is dominated by the United States, the United Kingdom and Czechoslovakia. While plastic refractory clay is produced widely, fire flint clay is restricted to Australia, Austria, China, France, Hungary, South Africa, United States and U.S.S.R.

Extensive development of kaolin deposits occurred in 1983 in Australia, Austria, Benin, Bulgaria, Cameroon, Nigeria, Oman, Spain and Sweden.

In the United States, shipments of clays in 1983 amounted to 90.8 million short tons valued at $US 931 million, an increase of 16 per cent in tonnage and 13 per cent in value compared to 1982. China clay accounts for 18 per cent of total production and 63 per cent of output in terms of value. Shipments of clay refractories amounted to $US 595,300 in 1983. American clay producers operated between 50 to 70 per cent of capacity. From a 1982 base, demand for clays is expected to increase at an average annual rate of 2 to 4 per cent to 1990. In anticipation of growth, the productive capacity for United States kaolin increased steadily since the early-1980s. This caused an excess in supply and generated lower profit margins for water-washed kaolin producers. In comparison, a shortage of capacity occurred for calcined grades used for paper filling and coating. Opening of new calcined kaolin plant facilities in Georgia were announced in 1984 by J.M. Huber Co., Wilkinson Kaolin Associates and Thiele Kaolin Co. Engelhard Corp. announced in late-1984 that it will purchase for $US 1 million Freeport Kaolin's operation in Gordon, Georgia. The purpose will be to increase the company's markets for pigments and extenders by expanding the capacity by

450 000 tons to 1.5 million tons. Kentucky-Tennessee Clay Co. the largest American producer of ball clay, was acquired by Ranchers Exploration and Development Corp. In Alabama, Donoho Clay Co. started a $US 1.4 million expansion plan to increase production of refractory clay.

## OUTLOOK

Clays and clay products are materials mainly characterized by high bulk, low unit value and sensitivity to transportation costs. Therefore, they are very sensitive to fluctuations in the general economic climate. In 1983, the increase in value of production was due to an increase in residential housing starts. This led to higher production of bricks in 1984. Construction activity rose in all provinces except Alberta where high vacancy rates persisted. From 1985 to 1990, total construction expenditures are forecast to grow at an annual rate varying between 2.5 per cent to 4.5 per cent. Expenditures in the industrial and non-residential building sectors are expected to be well above the average growth in the economy, while only modest growth is anticipated in the residential sector. A steady economic recovery would permit the construction materials sector to expand production where necessary and establish long-term plans to meet demand more efficiently. With confidence in lower interest rates, improved economic conditions and stimulative government housing programs, there could be a resurgence in housing starts.

Refractory product plants were on tight production schedules in 1984 as demand apparently shifted away from refractory clay products to alumina-based refractories for the steel, foundries, aluminum and cement industries. Meanwhile, acceptance of magnesia-carbon bricks is increasing in the United States. Consumption of refractories may rise slightly in the short-term, especially in Quebec, due to new smelter-related projects linked to the low cost of electrical energy.

The paper industry will remain the most important market for kaolin producers, both in terms of volume and value. As paper production is expected to increase steadily, consumption of coating-grade kaolin will in turn continue to increase through 1987. However, the outlook for filler grade clays is for little growth in the short term. Calcium carbonate is the major substitute for kaolin in the paper industry and consumption of super-fine ground calcite is expected to increase by 7 per cent per year. Given the present structure of the paper industry in North America it is unlikely that this substitution will happen in the short-term.

## PRICE QUOTATIONS FOR BALL CLAY AND KAOLIN

United States clay prices, according to Chemical Marketing Reporter, December 24, 1984.

| | $US per short ton |
|---|---|
| Ball clay, fob Tennessee | |
| Airfloated, bags, carload | 49.00 |
| Crushed, moisture repellent, bulk carload | 24.00 |
| Kaolin, fob Georgia | |
| Dry-ground, airfloated, soft | 60.00 |
| NF powdered, colloidal, 50 lb bags, 5,000 lb lots | .24/lb |
| Waterwashed, fully calcined, bags, carload | 255.00 |
| Waterwashed, uncalcined, delaminated paint grade, 1 micron average | 182.00 |
| Uncalcined, bulk, carload | |
| No. 1 coating | 94.00 |
| No. 2 coating | 75.00 |
| No. 3 coating | 73.00 |
| No. 4 coating | 70.00 |
| filler, general purpose | 58.00 |

Industrial Minerals, November 1984 quotation (£1.00=$US 1.50-1.70)

| | £ per tonne |
|---|---|
| Kaolin, refined, bulk, fob works | |
| Coating clays | 60-110 |
| Filler clays | 40-60 |
| Pottery clays | 25-65 |

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| CANADA | | | | | |
| 29500-1 | Clays, including china clay, fire clay and pipe clay not further manufactured than ground | free | free | free | free |
| 29525-1 | China clay | free | free | 25 | free |
| 28100-1 | Firebrick containing not less than 90 per cent silica; magnesite firebrick or chrome firebrick; other firebrick valued at not less than $100 per 1,000, rectangular shaped, not to exceed 100 x 25 in.$^3$ for use in kiln repair or other equipment of a manufacturing establishment | free | free | free | free |
| 28105-1 | Firebrick, nop, of a class or kind not made in Canada, for use in construction or repair of a furnace, kiln, etc. | free | free | 15 | free |
| 28110-1 | Firebrick, nop | 5 | 8.4 | 22.5 | 5 |
| 28200-1 | Building brick and paving brick | 8.1 | 7.5 | 22.5 | 5 |
| 28205-1 | Manufactures of clay or cement, nop | 10.8 | 10.3 | 22.5 | 6.5 |
| 28210-1 | Saggars, hillers, bats and plate setters, when used in the manufacture of ceramic products | free | free | free | free |
| 28215-1 | Grog, crushed or ground, but not further manufactured for use exclusively as refractory material per ton | free | free | $1.15 | free |
| 28300-1 | Drain tiles, not glazed | free | 13.9 | 20 | free |
| 28400-1 | Drain pipes, sewer pipes and earthenware fittings therefore; chimney linings or vents, chimney tops and inverted blocks glazed or unglazed, nop | 15 | 15.7 | 35 | 10 |
| 28405-1 | Earthenware tiles, for roofing purposes | free | 13.9 | 35 | free |
| 28415-1 | Earthenware tiles, nop | 12.5 | 16.3 | 35 | 10.5 |
| 28416-1 | Biscuits larger than 135 cm$^2$ in dimension containing not less than 50 per cent by weight of silica, kaolin and limestone for use in the manufacture of ceramic wall tiles (expires June 30, 1984) | free | free | 35 | free |
| 28500-1 | Tiles or blocks of earthenware or of stone prepared for mosaic flooring | 15 | 16.3 | 30 | 10.5 |
| 28600-1 | Earthenware and stoneware, viz: demijohns, churns or crocks, nop | 16.7 | 15.7 | 35 | 10 |

**TARIFFS** (cont'd)

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| CANADA (cont'd) | | | | | |
| 28700-1 | All tableware of china, porcelain, semi-porcelain or white granite, excluding earthenware articles | free | 15 | 35 | free |
| 28705-1 | Articles of chinaware, for mounting by silverware manufacturers | 12.5 | 13.9 | 22.5 | 9.0 |
| 28710-1 | Undecorated tableware of china, porcelain, semi-porcelain for use in the manufacture of decorated tableware | free | 8.4 | 35 | free |
| 28715-1 | Undecorated whiteware not less than 1/8 inch in thickness for use in the manufacture of decorated heavy duty tableware (expires June 30, 1984) | free | free | 35 | free |
| 28800-1 | Stoneware and Rockinghamware and earthenware, nop | 15.7 | 15.7 | 35 | 10 |
| 28805-1 | Chemical stoneware | free | 8.4 | 35 | free |
| 28810-1 | Hand forms of porcelain for manufacture of rubber gloves | free | free | 35 | free |
| 28900-1 | Baths, bathtubs, basins, closets, closet seats and covers, closet tanks, lavatories, urinals, sinks and laundry tubs of earthenware, stone, or cement, clay or other material, nop | 12.5 | 15 | 35 | 10 |
| 30000-1 | Crucibles and covers, nop | free | 8.4 | 15 | free |
| 44515-1 | Porcelains all of one piece, over eighty-six inches in length or having an outside diameter greater than twenty-four inches, for use in the manufacture of electric instrument and power transformers (expires June 30, 1984) | free | free | 37.5 | free |
| 44518-1 | Electric insulators of all kinds, nop | 12.8 | 12.1 | 27.5 | 8.0 |
| 44518-2 | Ceramic insulator spark plug cores not further manufactured than burned and blazed | 12.8 | free | 27.5 | free |
| 44518-3 | Porcelain or ceramic insulators, nop and complete parts thereof | 15 | 15 | 27.5 | 10 |
| 44519-1 | Porcelain or ceramic bushings for use in the manufacture of hermetically sealed power capacitors (expires June 30, 1984) | free | free | 27.5 | free |
| 49203-1 | Ceramic discs for use in the manufacture of carrier assemblies for multi-orifice valves (expires June 30, 1984) | free | free | 20 | free |
| 62430-1 | Statues and statuettes of porcelain or earthenware | free | 13.9 | 30 | free |

**TARIFFS** (cont'd)

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |

MFN Reductions under GATT (effective January 1 of year given)

| Item No. | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 28110-1 | Firebrick, nop | 8.4 | 8.0 | 7.6 | 7.2 | 6.8 |
| 28200-1 | Building brick and paving brick | 7.5 | 6.9 | 6.3 | 5.6 | 5.0 |
| 28205-1 | Manufactures of clay or cement, nop | 10.3 | 9.7 | 9.1 | 8.6 | 8.0 |
| 28300-1 | Drain tiles, not glazed | 13.9 | 12.9 | 12.0 | 11.1 | 10.2 |
| 28400-1 | Drain pipes, sewer pipes and earthenware fittings therefore; chimney linings or vents, chimney tops and inverted blocks glazed or unglazed, nop | 15.7 | 14.6 | 13.5 | 12.4 | 11.3 |
| 28405-1 | Earthenware tiles, for roofing purposes | 13.9 | 12.9 | 12.0 | 11.1 | 10.2 |
| 28415-1 | Earthenware tiles, nop | 16.3 | 15.3 | 14.4 | 13.4 | 12.5 |
| 28500-1 | Tiles or blocks of earthenware or of stone prepared for mosaic flooring | 16.3 | 15.3 | 14.4 | 13.4 | 12.5 |
| 28600-1 | Earthenware and stoneware, viz: demijohns, churns or crocks, nop | 15.7 | 14.6 | 13.5 | 12.4 | 11.3 |
| 28700-1 | All tableware of china, porcelain, semi-porcelain or white granite, excluding earthenware articles | 15.0 | 14.6 | 13.5 | 12.4 | 11.3 |
| 28705-1 | Articles of chinaware, for mounting by silverware manufacturers | 13.9 | 12.9 | 12.0 | 11.1 | 10.2 |
| 28710-1 | Undecorated tableware of china, porcelain, semi-porcelain for use in the manufacture of decorated tableware | 8.4 | 8.0 | 7.6 | 7.2 | 6.8 |
| 28800-1 | Stoneware and Rockinghamware and earthenware, nop | 15.7 | 14.6 | 13.5 | 12.4 | 11.3 |
| 28805-1 | Chemical stoneware | 8.4 | 8.0 | 7.6 | 7.2 | 6.8 |
| 28900-1 | Baths, bathtubs, basins, closets, closet seats and covers, closet tanks, lavatories, urinals, sinks and laundry tubs of earthenware, stone, or cement, clay or other material, nop | 15.0 | 14.6 | 13.5 | 12.4 | 11.3 |

UNITED STATES (MFN)

| | | (¢ per long ton) |
|---|---|---|
| 521.41 | China clay or kaolin | 33.0 |
| 521.81 | Other clays, not beneficiated | free |
| 521.84 | Other clays, wholly or partly beneficiated | 50.0 |

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | (¢ per long ton) | | | |
| 521.71 | Common blue clay and other ball clays, not beneficiated | 40.0 | 39.5 | 39.0 | 38.5 | 38.0 |
| 521.74 | Common blue clay and other ball clays wholly or partly beneficiated | 81.0 | 80.0 | 79.0 | 78.0 | 77.0 |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1983), USITC Publication 1317, U.S. Federal Register, Vol. 44, No. 241.
nop - Not otherwise provided for.
Note: In addition to the above tariffs various duties are in existence on manufactured clay products, viz., brick pottery, artware, etc.

## TABLE 1. CANADA, PRODUCTION OF CLAYS AND CLAY PRODUCTS FROM DOMESTIC SOURCES, 1982-84

| | 1982 | 1983P | 1984e |
|---|---|---|---|
| | | ($000) | |
| Production from domestic sources, by provinces | | | |
| Newfoundland | 860 | 1,381 | 1,600 |
| Nova Scotia | 4,500 | 5,900 | 6,700 |
| New Brunswick | 2,200 | 3,200 | 3,550 |
| Quebec | 14,047 | 20,667 | 20,430 |
| Ontario | 52,229 | 74,673 | 86,130 |
| Manitoba | 1,735 | 3,395 | 2,300 |
| Saskatchewan | 3,349 | 3,572 | 3,740 |
| Alberta | 11,220 | 12,207 | 8,775 |
| British Columbia | 5,853 | 7,335 | 7,680 |
| Total Canada | 95,993 | 132,329 | 140,905 |
| Production[1] from domestic sources, by products | | | |
| Brick - soft and stiff mud process and dry press | 71,643 | 98,982 | 105,680 |
| Drain tile | 4,651 | 4,764 | 5,635 |
| Sewer pipe | (2) | (2) | (2) |
| Flue linings | 2,296 | 3,308 | 4,230 |
| Pottery glazed or unglazed (including coarse earthenware, stoneware and all pottery) | (2) | (2) | (2) |
| Other products | 11,702 | 17,600 | 18,315 |
| Small establishments not reporting detail | 5,701 | 7,675 | 7,045 |
| Total | 95,993 | 132,329 | 140,905 |

Source: Statistics Canada.

[1] Producers' shipments. Distribution for 1983 estimated by Energy, Mines and Resources Canada. (2) Included in "Other products".

P Preliminary; e Estimated.

**TABLE 2. CANADA, IMPORTS AND EXPORTS OF CLAYS, CLAY PRODUCTS AND REFRACTORIES, 1982**

| | 1982 | | 1983P | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| | | | | | (Jan.-Sept.) | |
| **Imports** | | | | | | |
| Clays | | | | | | |
| China clay, ground or unground | 205 952 | 22,254 | 249 829 | 28,534 | 195 042 | 24,445 |
| Fire clay, ground or unground | 33 574 | 2,782 | 30 065 | 2,315 | 33 107 | 2,373 |
| Clays, ground or unground nes | 105 856 | 7,803 | 89 117 | 6,932 | 75 476 | 5,839 |
| Bentonite | 238 069 | 12,340 | 187 218 | 9,545 | 234 422 | 11,071 |
| Fuller's Earth | 1 081 | 75 | 536 | 75 | 3 177 | 408 |
| Drilling mud | 11 355 | 3,095 | 44 964 | 7,951 | 3 648 | 2,297 |
| Clays and earth, activated | 13 369 | 9,714 | 12 203 | 10,304 | 9 040 | 7,104 |
| Subtotal, clays | 609 256 | 58,063 | 613 932 | 65,656 | 553 912 | 53,617 |
| Clay Products | (M) | | (M) | | (M) | |
| Brick-building, glazed | 1 224 | 190 | 1 991 | 351 | 1 182 | 224 |
| Brick-building, nes | 13 818 | 2,544 | 25 208 | 4,223 | 23 940 | 4,387 |
| Building blocks and hollow tiles | .. | 1,541 | .. | 761 | .. | 693 |
| Brick acid-proof | .. | 131 | .. | 89 | .. | 59 |
| Clay bricks, blocks and tiles, nes | .. | 3,150 | .. | 4,211 | .. | 3,861 |
| Ceramic tiles | ($m^2$) | | ($m^2$) | | ($m^2$) | |
| under 2 1/2" x 2 1/2" | 705 566 | 5,492 | 544 942 | 3,984 | 453 835 | 3,571 |
| over 2 1/2" x 2 1/2" | 5 651 402 | 38,217 | 7 148 879 | 46,072 | 6 973 033 | 46,202 |
| Subtotal, bricks, blocks, tiles | .. | 51,265 | .. | 59,691 | .. | 58,997 |
| Tableware, ceramics | .. | 92,679 | .. | 93,068 | .. | 77,298 |
| Sanitaryware | .. | 166 | .. | 148 | .. | 48 |
| Artware | .. | 24,233 | .. | 25,449 | .. | 22,853 |
| Porcelain, electric insulators | .. | 31,666 | .. | 21,002 | .. | 23,704 |
| Chemical stoneware, exc. laboratory | .. | 1,166 | .. | 1,154 | | 999 |
| Pottery settings and firing supplies | .. | 975 | .. | 710 | .. | 329 |
| Pottery basic products, nes | .. | 1,705 | .. | 1,933 | .. | 2,449 |
| Clay end-products, nes | .. | 668 | .. | 1,451 | | 1,475 |
| Subtotal, ceramics | .. | 153,258 | .. | 144,915 | .. | 129,155 |
| Refractories | | | | | | |
| Fire brick and shapes | | | | | | |
| Alumina | 14 050 | 13,007 | 20 177 | 16,347 | 19 248 | 16,281 |
| Chrome | 190 | 222 | 533 | 492 | 733 | 962 |
| Magnesite | 12 461 | 11,174 | 18 928 | 19,093 | 15 463 | 18,598 |
| Silica | 2 984 | 2,406 | 3 027 | 2,671 | 3 018 | 2,772 |
| nes | 102 916 | 35,240 | 112 133 | 38,395 | 97 741 | 39,898 |
| Refractory cements and mortars | .. | 13,264 | .. | 14,456 | .. | 12,918 |
| Plastic fire brick and ramming mixture | .. | 1,342 | .. | 1,933 | .. | 929 |
| Crude refractory materials, nes | 9 457 | 1,831 | 7 148 | 1,213 | 7 059 | 1,562 |
| Grog (refractory scrap) | 5 339 | 778 | 4 655 | 476 | 3 764 | 401 |
| Foundry facings | .. | 1,012 | .. | 1,865 | .. | 1,583 |
| Refractories, nes | .. | 6,978 | .. | 7,287 | .. | 10,671 |
| Subtotal, refractories | .. | 87,254 | .. | 104,228 | .. | 106,575 |
| Total clays, clay products and refractories | .. | 349,840 | .. | 374,490 | .. | 348,344 |
| By main countries | | | | | | |
| United States | .. | 173,461 | .. | 186,351 | .. | 177 158 |
| Japan | .. | 40,751 | .. | 38,644 | .. | 43,421 |
| United Kingdom | .. | 48,746 | .. | 53,126 | .. | 37,785 |
| Italy | .. | 24,726 | .. | 26,490 | .. | 26,832 |
| West Germany | .. | 11,691 | .. | 17,807 | .. | 13,890 |
| Spain | .. | 8,081 | .. | 7,856 | .. | 9,351 |
| Taiwan | .. | 6,342 | .. | 6,919 | .. | 7,218 |
| Greece | .. | 4,341 | .. | 4,339 | .. | 4,217 |
| South Korea | .. | 3,904 | .. | 3,780 | .. | 4,186 |
| France | .. | 6,090 | .. | 5,713 | .. | 3,763 |
| People's Republic of China | .. | 5,215 | .. | 3,831 | .. | 2,950 |
| Brazil | .. | 1,818 | .. | 3,744 | .. | 2,807 |
| Hong Kong | .. | 1,579 | .. | 2,116 | .. | 2,220 |
| Other | .. | 13,095 | .. | 13,774 | .. | 12,546 |
| Total | .. | 349,840 | .. | 374,490 | .. | 348,344 |

TABLE 2. (cont'd)

| | 1982 | | 1983P | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| | | | | | (Jan.-Sept.) | |
| **Exports** | | | | | | |
| Clays, ground and unground | 557 | 40 | 272 | 66 | 501 | 123 |
| Clay products | (M) | | (M) | | (M) | |
| Building brick, clay | 2 138 | 467 | 2 352 | 641 | 1 711 | 428 |
| Clay bricks, blocks, tiles, nes | .. | 2,085 | .. | 1,496 | .. | 1,605 |
| Subtotal, bricks, blocks, tiles | .. | 2,552 | .. | 2,137 | .. | 2,156 |
| High-tension insulators and fittings | .. | 4,392 | .. | 3,447 | .. | 3,173 |
| Tableware, nes | .. | 9,718 | .. | 8,770 | .. | 6,140 |
| Subtotal, porcelain, tableware | .. | 14,110 | .. | 12,217 | .. | 9,313 |
| Refractories | | | | | | |
| Fire brick and shapes | 33 041 | 20,287 | 32 181 | 20,480 | 28 309 | 16,297 |
| Crude refractory materials | 40 839 | 150 | 241 127 | 955 | 422 231 | 1,733 |
| Refractory nes | .. | 13,388 | .. | 20,159 | .. | 24,799 |
| Subtotal refractories | .. | 33,825 | .. | 41,594 | .. | 42,829 |
| Total clays, clay products and refractories | .. | 50,527 | .. | 56,014 | .. | 54,298 |
| By main countries | | | | | | |
| United States | .. | 30,606 | .. | 41,426 | .. | 41,946 |
| Cuba | .. | 1,217 | .. | 743 | .. | 1,871 |
| Dominican Republic | .. | 645 | .. | 2,129 | .. | 1,087 |
| South Africa | .. | 875 | .. | 734 | .. | 967 |
| Algeria | .. | 12 | .. | 566 | .. | 749 |
| Australia | .. | 955 | .. | 612 | .. | 689 |
| New Zealand | .. | 936 | .. | 828 | .. | 654 |
| United Kingdom | .. | 723 | .. | 747 | .. | 381 |
| Colombia | .. | 913 | .. | 2,073 | .. | 257 |
| Trinidad-Tobago | .. | 1,491 | .. | 696 | .. | 156 |
| Belgium-Luxembourg | .. | 364 | .. | 370 | .. | 109 |
| Other countries | .. | 11,790 | .. | 5,090 | .. | 5,432 |
| Total | .. | 50,527 | .. | 56,014 | .. | 54,829 |

Source: Statistics Canada.
P Preliminary; .. Not available; nes Not elsewhere specified; M = Thousands; $m^2$ = Square metres.

**TABLE 3. CANADA, SHIPMENTS OF REFRACTORIES, 1980-82**

| | 1980 | | 1981 | | 1982 | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| Monolithics | 42 852 | 19,555 | 25 103 | 14,026 | 28 948 | 18,404 |
| Fire brick and shapes | 134 671 | 73,664 | 122 413 | 66,034 | 87 066 | 52,781 |
| Cement and mortars | 39 402 | 13,842 | 56 558 | 18,026 | 46 004 | 15,198 |
| All other products | ... | 28,596 | ... | 34,002 | ... | 26,753 |
| Total | ... | 135,657 | ... | 132,088 | ... | 113,136 |

Source: Statistics Canada.
... Figures not appropriate or not applicable.

**TABLE 4. CANAD, CLAYS, CLAY PRODUCTS AND REFRACTORIES, PRODUCTION AND TRADE, 1970, 1975, 1979-83**

| | Production | | | | | |
|---|---|---|---|---|---|---|
| Year | Domestic Clays | Imported Clays[2] | Total | Refactory Shipments[1] | Imports | Exports |
| | | | ($million) | | | |
| 1970 | 51.8 | 33.6 | 85.4 | 42.3 | 81.2 | 15.6 |
| 1975 | 78.4 | 59.1 | 137.5 | 65.0 | 177.4 | 25.1 |
| 1979 | 121.5 | 71.4 | 192.9 | 139.7 | 323.1 | 61.2 |
| 1980 | 108.5 | 83.4 | 191.9 | 135.7 | 386.2 | 63.8 |
| 1981 | 119.1 | 85.1 | 204.2 | 132.1 | 432.0 | 65.7 |
| 1982 | 96.0 | 63.4 | 159.4 | 113.1 | 349.8 | 50.5 |
| 1983P | 123.2 | .. | .. | .. | 374.5 | 56.0 |

Source: Statistics Canada.
[1] Includes fire brick and shapes, refractory cements, mortars, and monolithics, plus all other products shipped. [2] Includes electrical porcelains, glazed floor and wall tile, sanitaryware, pottery, art and decorative ware plus all other products.
P Preliminary; .. Not available.

## TABLE 5. CANADA, CONSUMPTION (AVAILABLE DATA) OF CLAYS, BY INDUSTRIES, 1981-83

|  | 1981 | 1982 | 1983P |
|---|---|---|---|
|  |  | (tonnes) |  |
| **China Clay** |  |  |  |
| Pulp and paper products[1] | 85 555 | 96 333 | 97 235 |
| Ceramic products | 9 764 | 6 680 | 10 267 |
| Paint and varnish | 5 955 | 5 510 | 6 082 |
| Rubber and linoleum | 4 033 | 5 951 | 6 568 |
| Other products[2] | 21 917 | 74 513 | 21 176 |
| Total | 127 224 | 188 987 | 141 328 |
| **Ball Clay** |  |  |  |
| Ceramic products misc. | 18 694 | 11 084 | 19 749 |
| Refractories | 2 743 | 11 969 | 2 578 |
| Other[3] | 127 979 | 78 951 | 45 049 |
| Total | 149 416 | 102 004 | 67 376 |
| **Fire Clay** |  |  |  |
| Foundries | 11 731 | 8 936 | 8 829 |
| Refractories | 14 929 | 14 546 | 5 840 |
| Other[4] | 2 467 | 4 183 | 9 458 |
| Total | 29 127 | 27 665 | 24 127 |

[1] Includes paper and paper products and paper pulp. [2] Includes refractory brick mixes, cements, glass fibre and wools, adhesives, foundry, wire and cable and other miscellaneous products. [3] Includes structural clay products, adhesives, miscellaneous chemicals, petroleum refining, paint and varnish and other miscellaneous products. [4] Includes abrasives, ceramic products, concrete products, paint and varnish, petroleum refining, and rubber products.
P Preliminary.

## TABLE 6. KAOLIN: WORLD PRODUCTION, 1981-83, MAJOR COUNTRIES

|  | 1981 | 1982P | 1983e |
|---|---|---|---|
|  |  | (000 tonnes) |  |
| United States | 6 950 | 5 770 | 6 530 |
| United Kingdom | 3 800 | 3 560 | 3 600 |
| U.S.S.R.e | 2 540 | 2 630 | 2 630 |
| Colombia[1] | 810 | 810 | 810 |
| Spain[3] | 790 | 700 | 700 |
| Czechoslovakia | 510 | 530 | 520 |
| West Germany | 470 | 450 | 500 |
| India[1] | 390 | 530 | 500 |
| Brazil[2] | 470 | 490 | 490 |
| Romania | 410 | 410 | 410 |
| France | 330 | 350 | 350 |
| Others | 3 040 | 2 380 | 3 130 |
| Total | 20 510 | 19 140 | 20 170 |

Source: U.S. Bureau of Mines, 1983, clays, Preprints of Minerals Yearbook, S. Ampian.
[1] Crude saleable kaolin. [2] Processed.
[3] Included crude and washed kaolin.
e Estimated; P Preliminary.

TABLE 7. MAJOR CANADIAN MANUFACTURERS OF STRUCTURAL CLAY PRODUCTS AND REFRACTORIES, 1984, BY PROVINCE

| Company | Plant Location | Products | Raw Material | Size$^1$ and Remarks |
|---|---|---|---|---|
| **NEWFOUNDLAND** | | | | |
| Trinity Brick Products Ltd. | St. John's | brick, building | shale | (B) |
| **NEW BRUNSWICK** | | | | |
| L.E. Shaw Limited | Chipman | brick, facing; tiles, drainage and partition | shale | (E) |
| **NOVA SCOTIA** | | | | |
| L.E. Shaw Limited | Lantz | bricks, blocks and tiles | common clay<br>ball clay | (E) |
| **QUEBEC** | | | | |
| Brique Citadelle Ltée | Beauport | bricks, facing and building, drain tiles and flue linings | shale | (-) |
| Compagnie 124984 Canada Ltée | Westbury | brick, facing | common clay | (A) formerly Quéabrique, also East Angus Brick & Tiles |
| Didier Corp. Refractaires | Becancour | bricks and shapes monoliths and mortars | alumina-silica silica | (E) |
| Domtar Inc. Construction materials div. | Laprairie | bricks, building and facing | shale | (G) |
| Dresser Canada Inc. Canadian refractories div. | Grenville | bricks and shapes monoliths | alumina-silica and basic (MgO) | (F) |
| Duquesne Refractories Ltd. | Montreal | monoliths and mortar | alumina-silica, silica and carbon | (A) |
| La Brique de Scott Ltée. | Scott-Junction | bricks and tiles | common clay | Closed since 1982 |
| La Briquerie St-Laurent Inc. | Laprairie | bricks, building and facing | shale | (C) |
| Montreal Terra-Cotta (1966) Ltée | Deschaillons | bricks, building, tiles and flue linings | shale, common | (B)<br>clay |
| Quigley Canada Inc. | Lachine | bricks and shapes cements | fire clay, basic (Mg0) | (A) |

TABLE 7. (cont'd)

| Company | Plant Location | Products | Raw Material | Size[1] and Remarks |
|---|---|---|---|---|
| **ONTARIO** | | | | |
| Amos C. Martin Ltd. | Park Hill | drain tiles | shale | (-) |
| A.P. Green Refractories | | | | |
| Acton div. | Acton | bricks and shapes | alumina-silica | (D) |
| Weston div. | Weston | monoliths | alumina-silica | |
| Babcock and Wilcox Refractories | Burlington | bricks and shapes<br>monoliths,<br>mineral wool | alumina-silica<br>kaolin | (C) |
| Barrie Brick Co. Ltd. | Midhurst | bricks, building | - | (-) |
| Bimac Canada Metallurgical Inc. | Burlington | bricks and shapes | - | (B) |
| BMI Refractories Inc. | Smithville | monoliths and mortars | - | (-) |
| Brampton Brick Ltd. | Brampton | bricks, building and facing | shale | (-) |
| Canada Brick Co. Ltd. | | | | |
| Burlington div. | Burlington | bricks, building | shale | (E) |
| F.B. McFarren div. | Streetsville | bricks, building | shale | |
| Streetsville div. | Streetsville | bricks, building | shale | |
| Dochart Clay Products Co. Ltd. | Arnprior | tiles | common clay | (B) |
| Domtar Inc. | | | | |
| Construction materials div. | | | | |
| Mississauga div. | Mississauga | bricks, building | shale | (G) |
| Ottawa div. | Ottawa | bricks, building | shale | |
| Dresden Tiles Yard (1981) Ltd. | Dresden | bricks, facing and building, tiles and flue liners | - | (A) |
| General Refractories Co. of Canada Ltd. | Smithville | bricks and shapes<br>mortars | alumina-silica, basic (MgO) | (D) |
| Georges Coultis and Sons Ltd. | Thedford | tiles, drain tiles | - | (B) |
| Halton Ceramics Ltd. | Burlington | blocks and tiles | common clay and shale | (A) |
| Hamilton Bricks Ltd. | Hamilton | bricks, building | shale | (B) |
| Kaiser Refractories Co. | Oakville | monoliths and mortars | alumina-silica and basic | (C) |
| Meaford Tiles Ltd. | Wallenstein | - | - | (-) |

TABLE 7. (cont'd)

| Company | Plant Location | Products | Raw Material | Size[1] and Remarks |
|---|---|---|---|---|
| **ONTARIO** (cont'd) | | | | |
| National Sewer Pipe Ltd. | Oakville | flue linings and sewer pipes | shale and fire clay | (-) |
| North American Refractories Ltd. | Haldimand | monoliths and mortars | alumina-silica | (B) |
| Norwich Brick and Tile Yard (1975) Ltd. | Norwich | - | - | (-) |
| Paisley Brick and Tile Co. Ltd. | Paisley | - | - | (-) |
| Plibrico (Canada) Ltd. | Burlington | monoliths and mortars | alumina-silica | (E) |
| R&I Ramtite Canada (Ltd.) C-E Refractories | Welland | monoliths and mortars; bricks | alumina-silica and basic | (C) |
| Toronto Brick Co. | Toronto | brick, facing and building | shales | (D), closed in 1984 |
| **MANITOBA** | | | | |
| I-XL Industries Ltd. Red River Brick and Tiles div. | Lockport | bricks and tiles | common clay | (E) |
| **SASKATCHEWAN** | | | | |
| A.P. Green Refractories (Canada) | Claybank | bricks and shapes | alumina-silica | (B) |
| Estevan Brick Ltd. | Estevan | bricks, building and facing | ball clay | (C) |
| I-XL Industries Ltd. Western Clay Products div. | Regina | bricks facing flue lining and sewer-pipe | - | Closed in 1982 |
| **ALBERTA** | | | | |
| I-XL Industries Ltd. | | | | (E) |
| Medicine Hat Brick and Tiles div. | Medicine Hat | bricks, blocks, tiles | common clay | |
| Medicine Hat Sewer Pipe div. | Medicine Hat | sewer pipes and flue lines | common clay | |
| Northwest Brick and Tiles div. | Edmonton | bricks, building | common clay | |
| Redcliff Pressed Bricks div. | Redcliff | brick, facing and fire brick | common clay<br>fire brick | |
| **BRITISH COLUMBIA** | | | | |
| Clayburn Refractories Ltd. | Abbotsford | bricks, mortars and monoliths | alumina-silica | (D) |
| Fairey and Company Ltd. | Surrey | bricks and shapes, monoliths, mortars | alumina-silica | (A) |

Sources: Statistics Canada; Mineral Policy Sector; Energy, Mines and Resources Canada.
[1] Size keys: (A) up to 25 employees; (B) 25-49; (C) 50-99; (D) 100-199; (E) 200-499; (F) 500-999; (G) over 1000 employees.
- Information not available.

# Coal and Coke

J.A. AYLSWORTH

The Canadian coal industry continued to set new records in 1983 and 1984 despite difficult market conditions brought on by the recent world recession and changes in energy supply-demand situations in many countries using coal as an energy fuel. Coal production, domestic consumption, exports and imports reached record levels in Canada in 1983 and again in 1984. Production and exports increased as a result of decisions taken, particularly by Japan, in 1980 and 1981 during a period of tight markets and supply shortfalls in the United States, Australia and Poland. New production capacity brought on-stream in Canada and Australia in 1983 combined with a resolution of delivery and port problems in the United States, Australia and Poland increased the supply of coal available for trade in international markets beginning in 1982. As this market adjustment was occurring the recession of the early 1980s resulted in reduced demand for coal in most major coal markets, putting significant downward pressures on both the volumes and prices of coal traded. The resulting supply-demand imbalance is expected to continue throughout the 1980s and will be further influenced by major new export capacity coming on in the U.S.S.R. and Columbia.

## COAL PRODUCTION AND DEVELOPMENTS

Canadian coal production is forecast to approach 57 million t of clean or saleable coal in 1984, up about 27 per cent over 1983. Production of coking coal increased due to five new mines which came on-stream in British Columbia and Alberta in 1983 and completed a full year's operation in 1984. Thermal coal production was up in 1984 over 1983 due to increased domestic demand, increased exports, and the development of one new mine in Alberta.

Coal production in Nova Scotia was up by about 4 per cent in 1984 in spite of a fire in May which resulted in the closure of No. 26 colliery in Glace Bay. As a result of the fire, output from this mine was only 200 000 t in 1984, down from nearly 700 000 t in 1983. Output from all Cape Breton Development Corporation's (CBDC) mines in 1984 was up marginally over 1983 due to significant increases in production from the Lingan mine. Exports by CBDC fell by about 50 per cent to 500 000 t as a result of the closure of No. 26 colliery. In late May the federal government unveiled a set of initiatives that will provide over $300 million of new capital investment to increase coal production and improve CBDS's commercial performance. The initiatives include: development of the Lingan-Phalen Colliery and expansion of the Victoria Junction preparation plant; completion of an exploratory tunnel to permit a detailed evaluation of the Donkin-Morien coal project; and construction of a wash plant and railway loading dock for the Prince mine. The new productive capacity created by these investments will ensure that sufficient coal is available to meet Nova Scotia's growing thermal coal requirements throughout the 1980s.

Coal production in New Brunswick grew by 3 per cent in 1984 to 575 000 t. Most of this coal is sold to the provincial utility for the generation of electricity. Coal production is forecast to remain at about this level throughout the remainder of this decade.

The five active coal mines in Saskatchewan are forecast to have produced a record 9.7 million t of coal in 1984, up 25 per cent over the 1983 level. The majority of this coal is marketed to mine mouth power stations, but a significant amount is shipped to power stations in western Ontario.

Alberta remains Canada's leading coal producing province with a 1984 estimated output of 22.8 million t, up 5 per cent over 1983. The production of sub-bituminous coal, which is used to generate electricity in mine mouth plants, accounted for 67 per cent of this total. The remaining output is bituminous coal which is sold domestically in Alberta and Ontario and internationally in Asian, European and other markets.

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Two new mines came on-stream in Alberta in 1983-84. A new coking coal mine operated by Gregg River Resources Ltd. (owned by Manalta Coal Ltd. and Japanese interests) produced about 700 000 t of coal in the latter part of 1983 and 2.0 million t of coal during its first full year of operation in 1984. All of this coal is marketed to steel mills in Japan. In the last quarter of 1984, the Obed Marsh Thermal Coal Project, (the Union Oil Company of Canada Limited) began production of thermal coal. Output in 1984 was 250 000 t, down somewhat from the planned level because of start-up problems. Output in 1985 is forecast to exceed one million t, destined primarily for European and Asian markets, and output could eventually reach 3 million t. During 1984 some Obed Marsh coal was shipped to Ontario Hydro power stations.

British Columbia's eight mines are forecast to have produced a record 20.6 million t of coal in 1984, up 75 per cent from the 1983 level of 11.7 million t. The main factor underlying this major increase was the first full year's production from four new mines which came on-stream in 1983. The Bullmoose (Teck Corporation) and the Quintette mines (Denison Mines Limited) in northeastern British Columbia produced 1.9 and 3.6 million t of coal respectively in 1984, compared with 200 000 and 100 000 t in 1983. Production from these mines should increase in 1985 as the Quintette operation overcomes start-up problems which constrained 1984s output. New mines in southeastern British Columbia, including the Greenhills mine (Westar Ltd.) and a new Line Creek mine (Crow's Nest Resources Limited), also contributed to the record British Columbia output, producing respectively 2.3 and 2.6 million t of coal in 1984.

## CANADIAN COAL UTILIZATION

Domestic coal utilization is expected to reach 50 million t in 1984, up 13 per cent from 1983. The utility sector remains the major domestic market in Canada, consuming 41 million t of coal in 1984, an increase of 13 per cent over 1983. This sector accounts for approximately 80 per cent of Canadian coal consumption and is forecasted to grow in relative and absolute terms through the remainder of this decade.

Thermal coal consumption grew by 50 per cent in Nova Scotia in 1984 and reached a record level of 2 million t. This increase reflected the first full year's operation of the MW Lingan #3 generating unit by the Nova Scotia Power Corporation and nearly half a year's operation of Lingan #4. Coal consumption will increase again in 1985 and in the latter years of the decade. Approximately 60 per cent of the province's electricity is now generated from coal compared with 19 per cent in 1979.

Most of the coal consumed in New Brunswick is used by the provincial utility, New Brunswick Electric Power Commission, to generate electricity at its Dalhousie and Grand Lake stations. Consumption in 1984 is forecast to be a record 600 000 t, up 6 per cent from 1983. Coal demand is forecast to remain at about this level for the foreseeable future.

Thermal coal consumption in Ontario approached a record level of 14 million t in 1984, up 8 per cent over 1983. About 3.6 million t, or 25 per cent of this total came from Canadian mines in British Columbia, Alberta and Saskatchewan with the other 75 per cent imported from the United States. The unexpected increase in 1984 occurred because of the shutdown of Units I and II of the Pickering nuclear generating station and because of higher than forecast electricity demands. Coal requirements may increase in 1985 as the new 200 MW Atikokan coal-fired station in western Ontario beginsits first full year of commercial operation, but the trend in the last half of this decade is for coal requirements to fall as more nuclear capacity comes on-stream. Forecasts indicate that by 1990 the amount of electricity generated from coal in Ontario will only be about one-half of 1984s level. However, thermal coal demand in Ontario may grow again in the 1990s.

Coal utilization in Manitoba was estimated at 160 000 t in 1984, up from 109 000 t in 1983. Although it is forecast that demand may exceed 250 000 t in 1985, coal consumption is unlikely to increase to significant levels in the future.

Thermal coal consumption grew by 14 per cent in Saskatchewan in 1984 reflecting increased electricity demand. Consumption is estimated at 7.5 million t, divided primarily between the Boundary Dam and Poplar River generating stations. A small amount of coal was also consumed at the Estevan generating station. Forecasts for 1985 indicate that coal demand will remain at about 1984's level, but may increase later in the decade. Late in 1984, Saskatchewan Power Corporation sold its Poplar River coal mine near Coronach to Manalta Coal Ltd. of Calgary. The Corporation will sign a 30 year contract to purchase coal from Manalta to fuel the nearby Poplar River generating station.

Thermal coal consumption in Alberta is forecast to be 16.7 million t in 1984, up 15 per cent from 1983. Most of this increase reflects the first full year's operation of TransAlta Utilities Corporation's new 800 MW Keephills generating station, which consumed 3.3 million t of coal in 1984. Coal demand will continue to increase for the remainder of the 1980s, although at a slower pace than previously forecast. Two new 750 MW generating stations are scheduled to be brought on-stream by 1990. The first 375 MW unit of the Sheerness Generation Station is to begin commercial operation by January 1986. The Genesee station near Edmonton is scheduled to come on-stream later on in the decade.

Consumption of coking coal increased by 15 per cent to 6.8 million t in 1984 as Canada's steel industry recorded increased sales in both domestic and export markets. The majority of the coal used in Canada to produce coke is imported from the United States. In 1984 Canada's three major Ontario-based steel companies (Dofasco Inc. and Stelco Inc. in Hamilton, and The Algoma Steel Corporation, Limited in Sault Ste. Marie) imported 6.6 million t of coking coal from the United States, up 20 per cent from 1983. These imports are expected to increase slowly throughout the remainder of the decade. Sydney Steel Corporation's ovens in Sydney, Nova Scotia, were shutdown in December 1983. They remain in a hot underfire mode, not producing coke but heated with propane, awaiting start-up. While these ovens produced no coke in 1984 plans call for a resumption of production in late-1985. A small amount of coal was used to produce coke in western Canada during 1984.

## EXPORTS AND IMPORTS

The international coal trade scene remains unbalanced with an excess of production capacity competing for slowly growing markets. Statistics for 1983 show that in spite of depressed international demands, Canada remained a net coal exporter, with exports reaching 17 million t and imports 14.6 million t. Exports of coking coal to Japan, which account for about two-thirds of all Canada's exports, remained at 10.9 million t in 1983, unchanged from 1982. This was a major achievement given that Japanese coking coal imports declined by 8 per cent in 1983 due to declining domestic and international steel demand. Nevertheless, in spite of the encouraging statistics, 1983 was a difficult year, due to the price cuts forced on Canada's exporters by the oversupplied market. Coking coal prices fell by approximately 15 per cent and virtually all existing mines were forced to accept volume cutbacks.

Preliminary statistics for 1984 indicate that Canadian coal exports will register an unprecedented increase of 48 per cent in 1984 over 1983. This increase is primarily the result of output from five new mines that began production in late-1983 and achieved nearly full production levels in 1984. In addition one new mine began producing thermal coal, primarily for the export market, late in 1984.

The six new mines include: the Quintette mine (Denison Mines Limited) and the Bullmoose mine (Teck Corporation) in northeastern British Columbia; the Line Creek coking coal mine (Crow's Nest Resources Limited) and Greenhills mine (Westar Mining Ltd.) in southeastern British Columbia; the Gregg River mine (Manalta Coal Ltd.) and the Obed Marsh mine (Union Oil Company of Canada Limited) in south central Alberta. Combined production from these mines in 1984 totalled about 12.7 million t compared with 3.4 million t in 1983. Virtually all of this output was destined for Japanese markets. Canadian coal will account for about 25 per cent of Japanese steel industry imports in 1984, compared with about 17 per cent in 1983.

Total exports in 1984 are forecast to be 25.2 million t compared with 17 million t in 1983. All of this increased tonnage will be exported through the three existing coal terminals in the Port of Vancouver's jurisdiction and through the new Ridley Terminal Inc. port near Prince Rupert. Exports through the three Vancouver terminals in 1984 totalled 19.5 million t compared with 16 million t in 1983. In its first year of operation, Ridley Terminals Inc. exported 5.2 million t of coal. Another 500 000 t of coal was exported through Sydney, Nova Scotia, to European, Latin American and other markets.

Although the volume of exports increased in the calendar year 1984, coal exporters in Canada and elsewhere are still experiencing difficult times. Average price fob, the port of export for existing Canadian producers in 1984, was down about 1 per cent over 1983. This normal price reduction on top of the major price cuts in 1983 resulted in renewed efforts by companies to cut costs and increase productivity. Most of the new mines, which had not been subject to the major price cutbacks of 1983 because they were not yet producing coal, agreed to contract adjustments late in 1984 which resulted in price decreases that took account of the current market conditions.

By the end of the year it became clear that 1984 crude steel production by the Japanese steel industry would surpass the 1983 level of 1 billion t by at least 5 per cent. This gave rise to the hope that the volume and price cuts of the last few years might be over and that producers might soon begin to realize some real price increases and recoup some volumes lost during the previous three years.

However, the large oversupply of coal still available in both coking and thermal coal markets and the uncertainty in world steel and energy markets forced first the United States, then Canadian, and finely Australian producers to unusually early contract settlements for fiscal year 1985-86. Several of the established producers in these three countries settled on new contracts with Japanese steel mills in October and November, months ahead of normal contract negotiations. The contracts basically left the 1984 prices unchanged but, in the case of some of the existing Canadian producers, provided for small increases in volumes of coal to be exported. This, coupled with the increases in volumes to be shipped from some of the new Canadian producers, should result in another record year for exports in 1985. Further increases in exports are anticipated for the last half of the 1980s, although the rate of year-to-year increases will moderate.

Two export oriented coal mines in British Columbia are under active development and hope to be producing in the next few years. The Quinsam Coal project on Vancouver Island (Brinco Limited) is actively looking for markets for its thermal coal. Trial shipments of anthracite coal from the Mount Klappan project (Gulf Canada Resources Inc.) in northwestern British Columbia were completed by year-end and more are scheduled for 1985. Other export coal projects under consideration for later in the 1980s include the McLeod River and Mercoal projects (Manalta Coal Ltd.) in Alberta and the Telkwa coal project (Crow's Nest Resources Limited) in north central British Columbia. The expansion of port capacity at Westshore Terminals Ltd. in 1984 and the opening of Ridley Terminals Inc. near Prince Rupert provided 22 million t of new export capacity for the Canadian coal industry, thereby ensuring adequate port capacity well into the 1990s.

Canadian coal imports are estimated to have reached 18.6 million t in 1984, up 27 per cent from the 1983 level of 14.6 million t. Most of this increase was accounted for by Ontario Hydro's imports which totalled 11.4 million t in 1984, up about 45 per cent from 1983. The three Canadian steel companies also increased their imports of coking coal in 1984 over 1983. Forecasts suggest that total imports will decline in the remainder of this decade due to Ontario Hydro's declining requirements for coal. Coking coal imports are forecast to increase slowly over the next few years.

TABLE 1. SUMMARY OF COAL SUPPLY BY TYPE AND VALUES, 1980-84

| | 1980 | | 1981 | | 1982 | | 1983 | | 1984[3] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (000 t) | ($000) | (000 t) | ($000) | (000 t) | ($000) | (000 t) | ($000) | (000 t) | ($000) |
| **DOMESTIC**[1] | | | | | | | | | | |
| **Bituminous** | | | | | | | | | | |
| Nova Scotia | 2 726 | 132,750 | 2 539 | 133,226 | 3 052 | 174,474 | 2 986 | 144,000 | 3 110 | 162,600 |
| New Brunswick | 439 | 17,269 | 524 | 23,308 | 499 | 24,450 | 558 | 29,000 | 575 | 30,300 |
| Alberta | 6 830 | 246,771 | 6 895 | 272,238 | 6 978 | 337,742 | 7 315 | 371,000 | 7 630 | 384,200 |
| British Columbia | 10 156 | 457,959 | 11 781 | 590,935 | 11 768 | 654,130 | 11 697 | 588,000 | 20 600 | 1,026,900 |
| Total | 20 151 | 854,749 | 21 739 | 1,019,707 | 22 396 | 1,190,796 | 22 556 | 1,132,000 | 31 915 | 1,604,000 |
| **Sub-bituminous** | | | | | | | | | | |
| Alberta | 10 542 | 55,402 | 11 551 | 42,559 | 13 021 | 88,022 | 14 464 | 112,000 | 15 170 | 131,300 |
| **Lignite** | | | | | | | | | | |
| Saskatchewan | 5 971 | 32,381 | 6 798 | 55,305 | 7 494 | 73,520 | 7 760 | 95,000 | 9 715 | 114,700 |
| Total | 36 664 | 942,532 | 40 088 | 1,117,571 | 42 811 | 1,352,398 | 44 780 | 1,339,000 | 56 800 | 1,850,000 |
| **IMPORTED**[2] | | | | | | | | | | |
| Bituminous & Anthracite Briquettes | 15 860 | 953,998 | 14 836 | 991,994 | 15 773 | 1,132,000 | 14 667 | 1,031,000 | 18 600 | .. |
| Total Coal Supply | 52 524 | 1,896,530 | 54 924 | 2,109,565 | 58 584 | 2,484,338 | 59 447 | 2,370,000 | 75 400 | |

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] fob mines; [2] Value at United States ports of exit. [3] Preliminary figures or estimates.
.. Not available.

TABLE 2. PRODUCER'S DISPOSITION OF CANADIAN COAL[1], 1983

| Destination | Nova Scotia | | New Brunswick | | Saskatchewan | | Alberta | | British Columbia | | Canada | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cok | Th | Cok | Th | Cok | Th | Cok | Th | Cok | Th | Cok | Th |
| | | | | | | (kilotonnes) | | | | | | |
| Newfoundland | - | 1 | - | - | - | - | - | - | - | - | - | 1 |
| Prince Edward Island | - | 12 | - | - | - | - | - | - | - | - | - | 12 |
| Nova Scotia | 91 | 1 835 | - | - | - | - | - | - | - | - | 91 | 1 835 |
| New Brunswick | - | 4 | - | 558 | - | - | - | - | - | - | - | 562 |
| Quebec | - | 28 | - | - | - | - | - | - | - | - | - | 28 |
| Ontario | - | - | - | - | - | 962 | - | 1 418 | - | 531 | - | 2 911 |
| Manitoba | - | - | - | - | - | 232 | - | 1 | - | 21 | - | 254 |
| Saskatchewan | - | - | - | - | - | 6 566 | - | 87 | - | 50 | - | 6 703 |
| Alberta | - | - | - | - | - | - | - | 14 485 | - | 1 | - | 14 486 |
| British Columbia | - | - | - | - | - | - | - | 1 | 25 | 34 | 25 | 35 |
| Total Canada | 91 | 1 880 | - | 558 | - | 7 760 | - | 15 992 | 25 | 637 | 116 | 26 827 |
| Japan | 50 | - | - | - | - | - | 3 743 | 421 | 6 355 | 276 | 10 148 | 697 |
| Other | 959 | 100 | - | - | - | - | 506 | 446 | 2 934 | 1 221 | 4 399 | 1 767 |
| Total shipments | 1 100 | 1 980 | - | 558 | - | 7 760 | 4 249 | 16 859 | 9 314 | 2 134 | 14 663 | 29 291 |
| Grand total | 3 080 | | 558 | | 7 760 | | 21 108 | | 11 448 | | 43 954 | |

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Saleable coal (raw coal, clean coal and middling sales).

Cok coking coal; Th thermal; - Nil.

TABLE 3. SUMMARY OF COAL SUPPLY-DEMAND, 1974-84

|  | CANADA PRODUCTION |  |  |  | IMPORTS |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|
| Year | Bituminous | Sub-Bituminous | Lignite | Total | Anthracite | Bituminous | Total Available | Domestic Consumption | Exports |
|  | (million tonnes) |  |  |  |  |  |  |  |  |
| 1974 | 12.5 | 5.1 | 3.5 | 21.1 | 0.4 | 12.0 | 33.5 | 24.9 | 10.5 |
| 1975 | 15.8 | 6.0 | 3.5 | 25.3 | 0.4 | 15.4 | 41.1 | 25.5 | 11.4 |
| 1976 | 14.4 | 6.4 | 4.7 | 25.5 | 0.3 | 14.3 | 40.1 | 28.2 | 11.9 |
| 1977 | 15.3 | 7.9 | 5.5 | 28.7 | 0.4 | 15.0 | 44.1 | 30.8 | 12.4 |
| 1978 | 17.1 | 8.3 | 5.1 | 30.5 | 0.3 | 13.8 | 44.6 | 31.7 | 14.0 |
| 1979 | 18.4 | 9.6 | 5.0 | 33.0 | 0.2 | 17.3 | 50.5 | 34.8 | 13.7 |
| 1980 | 20.2 | 10.5 | 6.0 | 36.7 | 0.3 | 15.5 | 52.5 | 37.3 | 15.3 |
| 1981 | 21.7 | 11.6 | 6.8 | 40.1 | 0.4 | 14.4 | 54.9 | 38.4 | 15.7 |
| 1982 | 22.3 | 13.0 | 9.5 | 42.8 | 0.3 | 15.5 | 58.6 | 41.5 | 16.0 |
| 1983 | 22.5 | 14.5 | 7.8 | 44.8 | 0.3 | 14.4 | 59.5 | 43.6 | 17.0 |
| 1984[1] | 31.9 | 15.2 | 9.7 | 56.8 | .. | .. | .. | 49.7 | 25.2 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Preliminary figures or estimates.

.. Not available.

### TABLE 4. CANADA, COAL PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION, 1979-84

| | Production | Imports | Exports | Domestic Consumption |
|---|---|---|---|---|
| | (000 tonnes) | | | |
| 1979 | 33 013 | 17 524 | 13 698 | 34 764 |
| 1980 | 36 664 | 15 829 | 15 269 | 37 333 |
| 1981 | 40 088 | 14 836 | 15 705 | 38 367 |
| 1982 | 42 811 | 15 773 | 16 004 | 41 478 |
| 1983 | 44 780 | 14 667 | 17 011 | 43 649 |
| 1984[1] | 56 800 | 18 600 | 25 200 | 49 700 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Preliminary figures or estimates.

### TABLE 6. EXPORT DEMAND FOR CANADIAN COAL, 1983

| Country | 1983 | |
|---|---|---|
| | (000 t) | ($000)[1] |
| Belgium-Luxembourg | 26 | 1,981 |
| Denmark | 296 | 14,992 |
| West Germany | 779 | 51,099 |
| Greece | 29 | 1,144 |
| Italy | 68 | 4,741 |
| Netherlands | 165 | 10,736 |
| Sweden | 218 | 14,999 |
| Algeria | 51 | 3,480 |
| Hong Kong | 210 | 10,906 |
| Pakistan | 139 | 10,828 |
| People's Republic of China | 17 | 1,302 |
| Japan | 10 996 | 829,863 |
| South Korea | 2 356 | 160,619 |
| Philippines | 35 | 1,361 |
| Taiwan | 552 | 39,233 |
| Argentina | 19 | 1,353 |
| Brazil | 716 | 54,028 |
| Chile | 120 | 9,158 |
| United States | 183 | 10,540 |
| Total | 16 978 | 1,232,000 |

Source: Statistics Canada.

[1] fob port of export Canadian dollars.

### TABLE 5. COAL USED BY THERMAL POWER STATIONS IN CANADA, BY PROVINCES, 1966-84

| | Nova Scotia | New Brunswick | Ontario | Manitoba | Saskatchewan | Alberta | Total Canada |
|---|---|---|---|---|---|---|---|
| | | | | (000 tonnes) | | | |
| 1966 | 799 | 294 | 3 500 | 79 | 1 116 | 1 360 | 7 148 |
| 1967 | 758 | 275 | 4 435 | 38 | 1 334 | 1 427 | 8 267 |
| 1968 | 646 | 240 | 5 523 | 179 | 1 354 | 2 128 | 10 070 |
| 1969 | 676 | 150 | 6 424 | 51 | 1 123 | 2 378 | 10 802 |
| 1970 | 548 | 113 | 7 696 | 503 | 1 969 | 2 951 | 13 780 |
| 1971 | 689 | 271 | 8 560 | 446 | 1 996 | 3 653 | 15 615 |
| 1972 | 663 | 281 | 7 599 | 410 | 2 145 | 4 113 | 15 211 |
| 1973 | 585 | 193 | 6 615 | 386 | 2 806 | 4 474 | 15 059 |
| 1974 | 606 | 292 | 6 721 | 132 | 2 902 | 4 771 | 15 424 |
| 1975 | 571 | 248 | 6 834 | 323 | 3 251 | 5 345 | 16 572 |
| 1976 | 730 | 207 | 7 612 | 979 | 3 521 | 5 996 | 19 045 |
| 1977 | 572 | 198 | 8 795 | 1 113 | 4 304 | 7 461 | 22 443 |
| 1978 | 771 | 151 | 9 097 | 341 | 4 585 | 8 029 | 22 914 |
| 1979 | 644 | 198 | 9 901 | 73 | 4 956 | 9 181 | 24 956 |
| 1980 | 1 052 | 315 | 10 779 | 240 | 4 972 | 10 424 | 27 782 |
| 1981 | 1 126 | 515 | 11 460 | 332 | 4 935 | 11 445 | 29 813 |
| 1982 | 1 300 | 548 | 12 484 | 184 | 5 897 | 13 242 | 33 656 |
| 1983 | 1 400 | 564 | 13 025 | 109 | 6 625 | 14 492 | 36 216 |
| 1984[1] | 2 000 | 600 | 14 000 | 160 | 7 500 | 16 700 | 40 960 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Preliminary figures or estimates.

## TABLE 7. SUMMARY OF COAL DEMAND, 1979-83

|  | 1979 | 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|---|
|  |  |  | (000 tonnes) |  |  |
| **DEMAND** |  |  |  |  |  |
| **Thermal Electric** |  |  |  |  |  |
| Canadian Coal | 16 104 | 19 314 | 20 998 | 24 033 | 26 748 |
| Imported Coal | 8 857 | 8 468 | 8 815 | 9 623 | 9 468 |
| Total | 24 961 | 27 782 | 29 813 | 33 656 | 36 216 |
| **Metallurgical** |  |  |  |  |  |
| Canadian Coal | 1 272 | 961 | 784 | 229 | 102 |
| Imported Coal | 6 593 | 6 279 | 5 593 | 5 347 | 5 481 |
| Total | 7 865 | 7 240 | 6 377 | 5 576 | 5 583 |
| **General Industry** |  |  |  |  |  |
| Canadian Coal | 963 | 1 190 | 962 | 1 075 | 667 |
| Imported Coal | 751 | 955 | 1 044 | 986 | 1 003 |
| Total | 1 714 | 2 145 | 2 006 | 2 061 | 1 670 |
| **Space Heating** |  |  |  |  |  |
| Canadian Coal | 200 | 166 | 171 | 185 | 180 |
| Imported Coal | 24 | - | - | - | - |
| Total | 224 | 166 | 171 | 185 | 180 |
| **Exports** |  |  |  |  |  |
| Canadian Coal | 13 698 | 15 269 | 15 705 | 16 004 | 17 011 |
| Total |  |  |  |  |  |
| Canadian Coal | 32 237 | 36 900 | 38 620 | 41 526 | 44 708 |
| Imported Coal | 16 225 | 15 702 | 15 452 | 15 956 | 15 952 |
| Total Coal Demand | 48 462 | 52 602 | 54 072 | 57 482 | 60 660 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.
- Nil.

## TABLE 8. CANADA, COKE PRODUCTION AND TRADE, 1973-83

|  | Production |  | Imports |  | Exports |  |
|---|---|---|---|---|---|---|
|  | Coal Coke | Petroleum Coke | Coal Coke | Petroleum Coke | Coal Coke | Petroleum Coke |
|  |  |  |  | (tonnes) |  |  |
| 1973 | 5 369 861 | 286 530 | 357 815 | 637 664 | 367 916 | 1 960 |
| 1974 | 5 443 427 | 274 412 | 509 058 | 746 033 | 260 892 | 24 940 |
| 1975 | 5 277 837 | 270 685 | 546 456 | 572 557 | 96 081 | 161 576 |
| 1976 | 5 289 185 | 678 432 | 287 249 | 591 859 | 169 895 | 136 970 |
| 1977 | 4 845 066 | 921 363 | 382 827 | 986 678 | 198 727 | 157 191 |
| 1978 | 4 967 664 | 1 014 076 | 553 349 | 973 985 | 217 595 | 134 762 |
| 1979 | 5 775 141 | 1 105 433 | 520 534 | 980 657 | 228 601 | 125 416 |
| 1980 | 5 249 744 | 1 156 444 | 626 923 | 908 322 | 319 554 | 150 200 |
| 1981 | 4 659 007 | 1 098 397 | 653 645 | 935 929 | 190 879 | 200 149 |
| 1982 | 3 999 117 | 1 083 129 | 453 915 | 650 810 | 129 793 | 104 897 |
| 1983 | 4 120 002 | 986 730 | 576 649 | 759 954 | 45 606 | 65 323 |

# Cobalt

R.G. TELEWIAK

Consumption of cobalt in the western world was close to 17 500 t in 1984 compared to 14 800 t in 1983. The United States is the largest market for cobalt, and strong economic activity in this country in 1984 was a major factor in the 18 per cent increase in world consumption. The other major markets of western Europe and Japan, showed a much lower increase.

Demand from the superalloy sector, which accounts for about one-third of the total, was particularly strong. This was led by the manufacture of new commercial and military jet engines, as well as normal replacement of jet engine parts, primarily turbine blades.

## CANADIAN DEVELOPMENTS

The two mine producers of cobalt, Inco Limited and Falconbridge Limited, recover cobalt as a byproduct of nickel-copper production. Due to an improvement in the nickel market, production of nickel increased by close to 30 per cent in 1984 over 1983. This resulted in a similar increase in cobalt production.

Inco Limited started production at its cobalt refinery at Port Colborne, Ontario in May 1983 and by year-end was producing at over two-thirds capacity. For most of 1984, the plant produced near its capacity of 900 tpy of electrolytic cobalt rounds.

Falconbridge Limited closed its Sudbury operations for two weeks during the summer of 1983 but in 1984 decided against taking a temporary closure. A series of rockbursts stopped production at the Falconbridge and East mines on June 20. In early July the company announced that after 35 years of operation, the Falconbridge mine would remain closed but the East mine would reopen. Production was increased at the mine to make up for this closure. At Kristiansand, Norway, Falconbridge continued to treat Sudbury matte and to refine some other feedstock from some other sources.

Output at the Fort Saskatchewan refinery of Sherritt Gordon Mines Limited was 539 t in the first nine months of 1984, a decline of 9 per cent from the comparable period in 1983. Sherritt Gordon toll refines feed for several producers and not as much material was available in 1984.

A joint venture consisting of Falconbridge and Geddes Resources Limited, carried out a drilling program in 1983 at the Windy Craggy copper-cobalt deposit in northwestern British Columbia. In late-1983 Falconbridge reduced its interest in the project to 22.5 per cent of net proceeds of production. In 1984, an underground exploration project was started. The deposit was reported to contain 318 million t of ore grading 1.5 per cent Cu and 0.08 per cent Co.

## WORLD DEVELOPMENTS

Zaire, which holds about one-half of the cobalt production capacity in the western world, regained much of its lost market share in 1983, after abandoning its producer pricing policy the previous year. In 1984, cobalt supply and demand came into close balance early in the year and Zaire was able to reinstitute its producer price in March.

In July 1984, Zaire announced that the state-owned metals marketing organisation, Société Zairose de Commercialisation des Minerais (Sozacom) would be dissolved. La Générale des Carrières et des Mines du Zaire (Gecamines), the state-owned mining company, also assumed responsibility for both production and marketing. The change was designed to streamline these operations. Both the World Bank and the International Monetary Fund were reported to be in favour of giving more marketing control to Gecamines.

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Zambia Consolidated Copper Mines Ltd. closed its Khana cobalt plant in 1983 and started producing from a new leach-electrowin facility. In 1984, Zambia continued to operate below capacity to keep inventories under control.

The General Services Administration (GSA) in the U.S. awarded contracts to Zaire and Zambia in 1983 for delivery of 2 948 t of cobalt to the national defence stockpile, at a price of $US 5.50/lb. In 1984, the United States awarded a contract to Inco for 227 t at $US 11.70/lb. These additional purchases will raise the stockpile to 23 914 t, or 62 per cent of the U.S. government's goal.

AMAX Inc. started in 1983 to ship its cobalt slurry to Fort Saskatchewan, Alberta for toll refining by Sherritt Gordon. Due to a shortage of nickel-copper matte, AMAX closed its Port Nickel refinery in Louisiana for two months in the summer of 1983 and for five weeks in 1984. AMAX obtains feed from BCL Limited in Botswana and Agnew Mining Co. Pty. Ltd. in Australia but these two sources are insufficient to keep the AMAX refinery operating at capacity for the full year.

In Japan, Sumitomo Metal Mining Co., Ltd. suspended cobalt production in early April 1984. Feedstock for the refinery had been obtained from Marinduque Mining and Industrial Corporation (in August renamed Nonoc Mining and Industrial Corporation) in the Philippines, but this operation was closed for most of 1984. The contract between Sumitomo and Nonoc Mining was cancelled late in the year and other refineries were being examined for treatment of Nonoc's concentrate. Sumitomo will continue to produce cobalt compounds from the small quantities of cobalt recovered in its nickel refinery.

## PRICES

In 1983, cobalt prices started from a low of $US 4.50-4.75/lb in early January and then peaked in April at $US 6.30-6.50. Speculative buying was a factor in the increase and when consumption did not respond as some anticipated, prices slipped to $US 5.35-5.45. By year-end they recovered to $US 5.95-6.10.

In 1984, prices advanced to $US 11.70/lb by the first week in March and then weakened slightly during the summer, before recovering to this same level by year-end. A major factor in the price rise and the relative stability of the price, was the action of the Zairean producer, Gecamines. The corporation, which is the largest producer in the world, pursued a marketing strategy to keep the price at these levels.

## USES

One of the major uses for cobalt is in superalloys where it improves the strength, wear and corrosion resistance characteristics of the alloys at elevated temperatures. The major use of cobalt-base superalloys is in turbine blades for aircraft jet engines and gas turbines for gas pipelines. Cobalt-base superalloys normally contain 45 per cent or more cobalt, while nickel- and iron-based superalloys contain 8 to 20 per cent cobalt.

Although the demand for cobalt in the production of magnets has been declining in recent years, this is still an important use for cobalt. Consumption of cobalt in this sector is almost one-half of what it was in 1970.

Cobalt-base alloys are used in applications where difficult cutting is involved and high abrasion resistance qualities are required. The most important group of cobalt-base alloys is the stellite group, containing cobalt, tungsten, chromium, and molybdenum as principal constituents. Hard-facing or coating of tools with cobalt alloys provides greater resistance to abrasion, heat, impact and corrosion.

Cobalt metal powder is used as a binder in making cemented tungsten carbides for heavy-duty and high-speed cutting tools.

As a chemical product, cobalt oxide is an important additive in paint, glass, and ceramics. Cobalt is also used to promote the adherence of enamel to steel for applications such as appliances, and steel to rubber for the construction of steel-belted tires. A cobalt-molybdenum-alumina compound is used as a catalyst in hydrogenation and in petroleum desulphurization.

## OUTLOOK

Over the long-term, cobalt consumption is expected to increase at an annual rate of 14.2 per cent. The price volatility over the past few years, particularly in the late-1970s when the prices peaked at over

$US 40/lb, has resulted in considerable substitution away from cobalt in certain uses and is a major factor in the forecast of a relatively modest increase.

Major consuming countries have expended considerable resources to find substitutes for cobalt in key applications. As an example of the results of these programs, the United States Air Force has developed two new cobalt-free superalloys which have excellent resistance to corrosion and oxidation. Although the precise composition have not been revealed, they are basically nickel aluminides. These alloys are being tested for application as gas turbine components for a new series of jet fighter engines.

Due primarily to the threat of substitution, the price of cobalt is not considered likely to advance significantly in real terms from its average level for 1984 of just over $US 11.50/lb. A substantially higher price would encourage more substitution and it would be in the long term interest of producers to not precipitate that type of action.

Zaire and Zambia are the two largest producers in the world, accounting for about two-thirds of cobalt capacity. The strategies which these two producers adopt, along with possible other events in these countries, will have a major impact upon supply and resultantly on prices and consumption.

## PRICES

| | Dec. 1983 | Dec. 1984 |
|---|---|---|
| | ($) | |
| Cobalt metal, per lb. | | |
| fob New York | | |
| Shot, 99.5%, 250-kg drum | 12.50[1] | 11.70 |
| Powder, 99%+ | | |
| 300 and 400 mesh, 50-kg drums | 6.91 | 13.24 |
| extra fine, 125-kg drums | 10.01 | 16.53 |

Source: Metals Week.
fob Free on board.
[1] Official price but transactions were taking place at considerably lower prices.

TABLE 1. CANADA, PRODUCTION TRADE 1982-84 AND CONSUMPTION 1981 AND 1982

| | 1982 | | 1983P | | 1984P | |
|---|---|---|---|---|---|---|
| | (kilograms) | ($) | (kilograms) | ($) | (kilograms) | ($) |
| **Production**[1] (all forms) | | | | | | |
| Ontario | 971 821 | 28,444,909 | 1 324 000 | 44,941,000 | 1 890 000 | 54,304,000 |
| Manitoba | 302 663 | 10,295,778 | 260 000 | 8,819,000 | 435 000 | 12,501,000 |
| Total | 1 274 484 | 38,740,687 | 1 584 000 | 53,760,000 | 2 325 000 | 66,805,000 |
| | | | | | (Jan.-Sept.) | |
| **Exports** | | | | | | |
| Cobalt metal | | | | | | |
| United States | 526 673 | 14,206,000 | 654 191 | 11,585,000 | 846 961 | 18,509 |
| United Kingdom | 1 696 | 17,000 | 107 974 | 3,805,000 | 136 716 | 1,923 |
| South Africa | 8 321 | 606,000 | 21 559 | 539,000 | - | - |
| Belgium-Luxembourg | - | - | 67 995 | 379,000 | 119 995 | 669 |
| Australia | 2 927 | 86,000 | 14 856 | 208,000 | 3 869 | 115 |
| Other countries | 45 388 | 984,000 | 18 707 | 330,000 | 4 442 | 156 |
| Total | 585 005 | 15,899,000 | 885 282 | 16,846,000 | 1 111 983 | 21,372,000 |
| Cobalt oxides and hydroxides[2] | | | | | | |
| United Kingdom | 230 000 | 8,521,000 | 184 000 | 6,061,000 | 248 000 | 3,975,000 |
| United States | - | - | 8 000 | 112,000 | 17 000 | 72,000 |
| Belgium-Luxembourg | - | - | - | - | 36 000 | 573,000 |
| Total | 230 000 | 8,521,000 | 192 000 | 6,173,000 | 301 000 | 4,620,000 |
| **Consumption**[3] | 1981 | | 1982 | | | |
| Cobalt contained in: | | | | | | |
| Cobalt metal | 87 583 | | 63 863 | | | |
| Cobalt oxide | 6 979 | | 10 070 | | | |
| Cobalt salts | 6 772 | | 12 456 | | | |
| Total | 101 334 | .. | 86 389 | .. | | |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Production (cobalt content) from domestic ores. [2] Gross weight. [3] Available data reported by consumers.
P Preliminary; - Nil; .. Not available.

## TABLE 2. CANADA, COBALT PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975 AND 1979-84

| | | Exports | | Imports | | |
|---|---|---|---|---|---|---|
| | Production[1] | Cobalt metal | Cobalt oxides and hydroxides | Cobalt ores[2] | Cobalt oxides and hydroxides[3] | Consumption[4] |
| | (tonnes) | | | | | |
| 1970 | 2 069 | 381 | 837 | .. | .. | 148 |
| 1975 | 1 354 | 431 | 561 | .. | .. | 123 |
| 1979 | 1 640 | 296 | 445 | 190 | 46 | 115 |
| 1980 | 2 118 | 325 | 1 091 | 2 | 26 | 105 |
| 1981 | 2 080 | 677 | 601 | 24 | 20 | 101 |
| 1982 | 1 274 | 585 | 212 | 2 | 30 | 86 |
| 1983P | 1 584 | 885 | 192 | 45 | 30 | 101 |
| 1984[5] | .. | 1 112 | 302 | 13 | 17 | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Production from domestic ores, cobalt content including cobalt content of Inco Limited and of Falconbridge Limited shipments to overseas refineries. [2] Cobalt content. [3] Gross weight. [4] Consumption of cobalt in metal, oxides and salts. [5] First 9 months.
P Preliminary; .. Not available.

## TABLE 3. MAJOR CANADIAN PRODUCER'S SHIPMENTS OF COBALT

| | 1981 | 1982 | 1983 |
|---|---|---|---|
| | (tonnes) | | |
| Inco | 1 642 | 1 148 | 812 |
| Falconbridge | 622 | 377 | 659 |
| Sherritt Gordon | 379 | 342 | 346 |

Source: Company Annual Report.

## TABLE 4. WORLD PRODUCTION OF COBALT

| | 1981 | 1982 | 1983e |
|---|---|---|---|
| | (tonnes) | | |
| Zaire | 15 420 | 11 300 | 11 300 |
| Zambia | 3 420 | 3 250 | 3 200 |
| Canada | 2 300 | 1 400 | 1 750 |
| Australia | 1 660 | 1 800 | 1 815 |
| Finland | 1 035 | 930 | 910 |
| Cuba | 1 715 | 1 500 | 1 650 |
| U.S.S.R. | 2 180 | 2 270 | 2 360 |
| Other | 3 288 | 1 904 | 1 142 |
| Total | 30 018 | 24 354 | 24 127 |

Source: United States Bureau of Mines.

# Columbium (Niobium)

D.G. FONG

## CANADIAN DEVELOPMENTS

Niobec Inc., Canada's sole columbium producer at St. Honoré, Quebec, is jointly owned by Société québécoise d'exploration minière (SOQUEM) and Teck Corporation. Production in 1983 was 1 815 t of columbium pentoxide ($Cb_2O_5$) contained in pyrochlore concentrate, a 42 per cent decline from 1982. This low production result was directly related to a shutdown at the mining operations from April 1 to August 22, 1983 because of high inventories.

Niobec's mine production was estimated at 2 770 t contained $Cb_2O_5$ in 1984. Apart from a strike which closed the mining operation from October 19 to November 29, production was maintained at near capacity level.

Niobec deferred its plans to build a high-purity-oxide plant, due to a limited market and an underutilization of existing world capacity. The company had been considering a 907 tpy plant at an estimated cost of $3.2 million.

Camchib Mines Inc. and New Venture Equities Ltd., which took over the Martison Lake phosphate-columbium property from Shell Canada Resources Limited in 1982, continued drilling and other evaluating work in 1983 and 1984. The property is located north of Hearst in northern Ontario. Drilling has outlined 140 million t of mineralization grading 0.35 per cent $Cb_2O_5$ and 20 per cent phosphate ($P_2O_5$).

## WORLD DEVELOPMENTS

### SUPPLY

Ferrocolumbium production (FeCb) in 1984 by Companhia Brasileira de Metalurgia e Mineração S.A. (CBMM) of Brazil, estimated at 15 000 t $Cb_2O_5$, more than doubled its output of 7 320 t in 1983. Exports in 1984 were estimated at 14 000 t of FeCb and 400 t of columbium oxide ($Cb_2O_5$), compared with 6 680 t of FeCb and 277 t of $Cb_2O_5$ in 1983. The weakness in sales in 1983 was attributed to economic recession and a draw-down of consumer inventories.

CBMM is owned 55 per cent by Metropolitana de Comércio e Participacões, a private Brazilian interest, and 45 per cent by Molycorp, Inc. of the United States. The company operates the world's largest columbium mine at Araxá in the State of Minas Gervais, and accounts for 90 per cent of Brazilian production. The remaining 10 per cent is produced by Mineração Catalão de Goiás S.A. in the Ouvidor-Catalão region of Goias state. The main international markets for CBMM's columbium products are Europe (42 per cent), Canada and the United States (27 per cent), Japan (17 per cent) and the U.S.S.R. (6 per cent).

In recent years, CBMM has placed a high priority on further processing. The company continued to work on its columbium metal project and has made small shipments on a trial basis. The 99.99 per cent pure metal is used as a coating for medical instruments, nuclear-magnetic resonance (NMR) spectrometers, and corrosion-resistant applications. However, the market at present is fairly small. In 1983, CBMM began the production of optical and crystal grade oxides for the optical and electronic industries. In addition, its 2 400 tpy high purity oxide plant was restarted in September 1983 after a shutdown of almost two years.

Productos Metalúrgicos S.A. (PROMETAL) and Metais Goiás S.A. (METAGO) formed a Brazilian joint venture in 1983 called Goiás Nióbio S.A. to bring a new mining and ferrocolumbium plant into operation in the state of Goiás. The deposit was reported to contain 9 million t with an average grade of 0.95 per cent $Cb_2O_5$. Goiásnnióbio was planning to bring the project into production at a rate of 1 100 tpy of ferrocolumbium in the latter part of 1984.

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A large columbium deposit was discovered in 1984 in São Gabriel da Cachoeira, Amazonas state by Companhia de Pesquisa de Recursos Minerais (CPRM), a Brazilian state mineral research organization. The deposit contains 2.9 billion t grading an average 2.81 per cent pyrochlore. This new discovery raised Brazilian columbium resources to 7.4 billion t, which is equivalent to about 92 per cent of the world's reserves.

Teledyne Wah Chang in the United States, produced high-purity columbium oxide at its Oregon plant using standard grade ferrocolumbium as feed material. The company also produced reactor-grade metal and powders. Operations during the last two years, however, have been at a reduced rate due to weak demand from the aerospace and nuclear industries. NRC Inc. continued to produce columbium oxide and metal at its Newton, Mass. plant. The company installed a new electron-beam furnace and a new rolling mill in 1982.

## DEMAND

Rising steel and automobile production have helped to raise columbium consumption during the last two years. Carbon steels showed the largest increase in 1983 while high-strength, low-alloy (HSLA) steels exhibited a strong recovery in the first half of 1984. Stainless steels and superalloys, also showed a significant increase, especially in 1984.

The increase in consumption of the HSLA steels came largely from the recovery in the automotive industry although consumption has also expanded in recent years due to new applications in automotive body parts and forged components such as crank shafts and engine mounts. The strong trend toward front-wheel-drive vehicles has created an additional demand for HSLA steel because of its use in trailing axle assemblies.

Other important end-uses, such as pipeline and structural steels began to show evidence of recovery in 1984. Higher construction activity helped to augment the demand for structural steels. Although large diameter linepipe has remained depressed during the last two years the consumption for smaller diameter gathering, transmission and distribution linepipe returned to the 1981 level.

The fastest growing market for stainless steels was in vehicle exhaust systems. In the United States, the consumption of stainless steels doubled during the first five months of 1984 compared with the corresponding period in 1983.

Superalloys were also in stronger demand, largely because there was an expansion in the production of military jet engines and spare parts for commercial jet engines.

## GOVERNMENT STOCKPILES

In August 1984, the General Services Administration (GSA) announced plans to purchase columbite concentrates containing 259 527 kg of $Cb_2O_5$ for the National Defense stockpile. Bids were invited to supply eight lots of concentrates with a minimum content of 45 per cent $Cb_2O_5$, a maximum of 0.10 per cent phosphate ($P_2O_5$), and a combined content of at least 60 per cent of $Cb_2O_5$ and tantalum pentoxide ($Ta_2O_5$). None of the bids were successful because the prices quoted in all of them were considered to be too high.

## USES

The steel industry is the largest consumer of columbium, which is used in the form of ferrocolumbium as an additive agent in HSLA steels, carbon steels, and stainless steels. Although the quantity of columbium may be as low as 0.02 per cent, the yield strength and mechanical properties of the resulting steel are significantly improved. These characteristics are particularly important in applications such as large-diameter pipeline, automotive components, structural applications and drilling platforms.

High-purity columbium pentoxide is used mainly in superalloys for turbine and jet engines, which have traditionally been the second largest use after steels. A columbium addition to the cobalt-and nickel-based superalloys improves the high-temperature characteristics of these alloys. In the manufacture of high-alloy and stainless steels, columbium is used to impart resistance to corrosion at elevated temperatures, a property of particular importance in petroleum processing plants, heat exchangers for severe chemical environments and acid pressure vessels.

One of the important properties of columbium is its superior conductivity compared with other pure metals.

Superconductivity is the loss of all resistance to direct electrical current at temperatures near absolute zero. This special property of columbium allows the construction of powerful electrical generators, which are much more efficient than conventional generators with copper wire windings. Also, because of the powerful magnetic field created by the superconductors, it is used extensively in the construction of nuclear magnetic resonance (NMR) spectrometers. In addition, many potential applications in electrical devices are being developed, including new types of motors, ship engines, electric generators and switch elements for computers.

Special high-purity columbium pentoxide is produced for optical applications. Additions of columbium pentoxide to optical glass give a high refractive index and thereby allow production of thin lenses for eyeglasses. This characteristic, along with others such as lightweight and durability, enable such lenses to be competitive with plastic lenses.

## PRICES

Prices for Canadian pyrochlore concentrates remained unchanged throughout 1983 and 1984. Niobec, the world's sole major supplier of concentrate since the Brazilian government banned exports of pyrochlore in 1981, quoted its price at $US 3.25 a lb. $Cb_2O_5$ contained in concentrate.

The quoted price for standard grade ferrocolumbium was unchanged at $US 6 a lb. contained columbium in 1983, but was lowered in the United States to $US 5.60 in February 1984, despite evidence of stronger demand. Niobium Products Company Ltd. (NPC) of Pittsburgh, a subsidiary of CBMM, initiated the price cut and stated that a reduction was necessary in order to stimulate demand and bring the U.S. price into line with European prices.

The price of high purity ferrocolumbium has been moving downward since CBMM introduced its high purity product into the U.S. market in 1982. The price fell from $US 21 a lb. in early 1983 to $US 17.70 in October 1984. NRC of Newton, Mass. raised its price for high purity columbium pentoxide in October 1983 by 10 per cent to $US 6.60 a lb. in response to an upturn in demand and low inventories. The higher price, matched later by CBMM, remained in effect for the balance of 1983 and in 1984.

## OUTLOOK

Improved steelmaking technology and lower steel requirements will continue to have a negative impact on the consumption of a number of ferroalloy products. The demand for ferrocolumbium, however, is expected to fare better than most other ferroalloys because of the advantages held by columbium steels, which result in substantial material savings for many steel applications. Also, columbium steels are not as yet widely produced in Asia. As Asia is increasingly becoming a steel manufacturing centre, demand for higher grade steels will likely rise and consumption of columbium will increase. In the long run, the demand for columbium in the western world is expected to grow between 4 and 5 per cent a year.

Microalloyed columbium steels are forecast to enjoy greater popularity in many applications, particularly in the automotive industry where weight reduction continues to offer scope for achieving higher fuel efficiency. The consumption of micro-alloyed steels in each 1983 car averaged 250 lbs as compared with none in 1973. This application is expected to increase to 375 lbs per car by 1990.

The Canadian steel industry has forecasted a demand increase from the pipe and tube industry of 5 per cent in 1985, based largely on an expectation that there will be increased activity in hydrocarbon developments in both Canada and the United States.

The content of columbium per t of stainless steel has been declining. With the advent of the argon-oxygen-decarburization (AOD) steelmaking process and the ability to decarburize to low levels, there is less need for columbium in stainless steels. However, this development is being offset to some degree by the growing consumption of ferritic stainless steels, used in higher temperature applications to resist corrosion.

The demand for superalloys is forecast to improve as commercial air carriers start to buy new airplanes with more fuel-efficient engines. Consumption is also forecast to increase for replacement parts in the air carrier industry. However, it will be at least the late 1980s before usage in this sector will reach its record level of 1980. The new fuel-efficient engines operate at higher temperatures and, accordingly, require materials such as high-columbium superalloys which can withstand this condition.

On the supply side, there will be adequate production capacity to meet the forecast demand increase. CBMM is in a position to double its 25 000 tpy pyrochlore plant whenever markets warrant. The recent discovery of a large pyrochlore deposit in the Amazon region could add another major producer by next decade. This major discovery reafirms Brazil's predominance as a columbium source.

Canada also has large resources, which occur in a number of undeveloped deposits across the country. In view of the strong growth potential for columbium, some of these deposits are likely to be mined in the next decade. The development of these deposits will enhance Canada's position as an important world columbium supplier. China and Zaire have reported discoveries which could result in new producers for these countries in the near-future.

Adequate supplies to satisfy growing demand and stability of price have been key factors in the success of columbium. These factors are expected to prevail in the foreseeable future, with the result that columbium should remain cost effective as a steel additive, particulary in relation to its closest alternative, vanadium.

## PRICES

Prices as quoted in Metals Week in December 1983 and 1984, U.S. currency.

| | 1983 | 1984 |
|---|---|---|
| | ($) | |
| Columbium ore | | |
| Columbite, per kg of pentoxide, cif U.S. ports[1] | 11.02-15.43 | 7.72-11.02 |
| Canadian pyrochlore, per kg, fob mine | 7.17 | 7.17 |
| Ferrocolumbium, per kg Cb, fob shipping point | | |
| Low alloy | 13.23 | 12.48 |
| High purity alloy | 43.54 | 39.02 |
| Columbium metal, per kg 99.5-99.8%, fas shipping point | | |
| Reactor ingot | 72.75-88.18 | 72.75-88.18 |
| Reactor powder | 79.37-105.82 | 79.37-105.82 |

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[1] The range reflects variations in the ratio of columbium pentoxide ($Cb_2O_5$) to tantalum pentoxide ($Ta_2O_5$).

cif - Cost, insurance and freight; fob - Free on board; fas - Free alongside ship.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| CANADA | | | | | |
| 32900-1 | Columbium and tantalum ores and concentrates | free | free | free | free |
| 35120-1 | Columbium (niobium) and tantalum metal and alloys in powder, pellets, scrap, ingots, sheets, plates, strips, bars, rods, tubing or wire for use in Canadian manufactures (expires June 30, 1984) | free | free | 25 | free |
| 37506-1 | Ferrocolumbium, ferrotantalum, ferro-tantalum-columbium | free | 4.7 | 5 | free |

**TARIFFS** (cont'd)

| MFN Reductions under GATT (effective January 1 of year given) | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 37506-1 | | 4.7 | 4.5 | 4.3 | 4.2 | 4.0 |
| UNITED STATES | | | | | | |
| 601.21 | Columbium ore | free | | | | |
| | | 1983 | 1984 | 1985 | 1986 | 1987 |
| | | | | (%) | | |
| 628.15 | Columbium metal, unwrought, and waste and scrap (duty on waste and scrap suspended to June 30, 1982) | 4.4 | 4.2 | 4.0 | 3.9 | 3.7 |
| 628.17 | Columbium, unwrought alloys | 6.2 | 5.9 | 5.6 | 5.2 | 4.9 |
| 628.20 | Columbium metal, wrought | 7.3 | 6.8 | 6.4 | 5.9 | 5.5 |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated 1983, USITC Publication 1317; U.S. Federal Register, Vol. 44, No. 241.

**TABLE 1. CANADA, COLUMBIUM (NIOBIUM) PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975 AND 1979-84**

| | Production[1] | Imports[3] | | Exports[2] | Consumption |
|---|---|---|---|---|---|
| | | Primary forms and fabricated metals | | | |
| | $Cb_2O_5$ Content | Columbium | Columbium Alloys | Columbium Ores and Concentrates to United States | Ferrocolumbium and Ferrotantalum-columbium, Cb and Ta-Cb Content |
| | (kilograms) | | | | |
| 1970 | 2 129 271 | .. | .. | 576 227 | 132 449 |
| 1975 | 1 661 567 | .. | .. | 9 682 | 215 910 |
| 1979 | 2 512 667 | 855 | W | 509 953 | 360 152 |
| 1980 | 2 462 798 | 877 | 156 | 655 721 | 486 251 |
| 1981 | 2 740 736 | 913 | 303 | 419 865 | 455 500r |
| 1982 | 3 086 000 | 805 | 59 | 291 193 | 356 000 |
| 1983 | 1 744 722 | 967 | 396 | 543 599 | 352 000 |
| 1984p | 2 500 000 | 684 | 104 | .. | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada; U.S. Department of Commerce.

[1] Producers' shipments of columbium ores and concentrates and primary products, $Cb_2O_5$ content. [2] From U.S. Department of Commerce, Imports of Merchandise for Consumption, Report FT 135. Quantities in gross weight of material. [3] 1984 imports based on nine month statistics.

p Preliminary; .. Not available; W Withheld to avoid disclosing confidential company data; r Revised.

# Copper

**W.J. McCUTCHEON**

Canadian copper producers reacted to low copper prices by increasing productivity to reduce costs or in some cases by shutting down. Concentrate producers shipping to Pacific Rim smelters benefitted from relatively low smelting treatment and refining charges. However, some Canadian smelters in central and eastern Canada faced concentrate shortages. Byproduct and coproduct metal prices remained relatively low and these contributed to the unfavorable financial performance of many producers.

Canadian copper shipments in 1983 were 653 040 tonnes (t) of recoverable (or if exported, paid for) copper and these increased to an estimated 712 000 t in 1984, reflecting more normal copper production by Inco Limited. Approximately 150 000 tpy of copper production capacity in Canada was closed at the end of 1984, either on a temporary or permanent basis. Canadian copper consumption (defined as shipments to domestic consumers) increased from 170 000 t in 1983 to an estimated 190 000 t in 1984.

Space does not permit a detailed review of all major events in 1983 and 1984 which appear in commercial publications and in monthly reviews by Energy, Mines and Resources Canada. Some of the major events in the regions of Canada and in the world are reviewed below.

## CANADIAN DEVELOPMENTS

ASARCO Incorporated mined out its Buchans mine in Newfoundland. At Noranda Inc.'s, Division Mines Gaspé at Murdochville, Quebec, the open-pit remained closed through 1983-84. Development of the E zone orebody below Murdochville commenced in 1984, and the recall of 250 workers began in August 1984 to reopen the 4 000 tpd underground mine. Corporation Falconbridge Copper resumed operations at its Lake Dufault Division in Rouyn-Noranda in April 1983. Exploration development at the 2 million t, 7 per cent Cu, 1.6 km deep Ansil orebody, began late 1984. Operation ceased at Northgate Patino Mines Inc.'s, Lemoine mine in March 1983, after producing 30 160 t of copper in seven years. BP Resources Canada started a $125 million development of the A1 zinc-copper orebody at its mine near Joutel. The 5 000 tpd pit should begin operations in 1986. The B zone underground production at 1 500 tpd should continue until 1990.

In the Sudbury district, Falconbridge Limited resumed production at its Sudbury operations in January, 1983 after a shutdown of six months. Inco ended its 10 month shutdown of its Sudbury operations in April 1983. Inco was the largest copper producer to shutdown in the western world in the 1982 recession.

Hudson Bay Mining and Smelting Co., Limited (HBMS) became a subsidiary of Inspiration Resources Corporation of New York. The Centennial and Westarm mines require new development which cannot be justified at low metal prices and were temporarily closed. The White Lake mine ore reserves were exhausted while Trout Lake mine was brought up to its rated production level of 1 600 tpd. The Rod mine produced at its rated capacity in 1984. Exploration for new reserves is under way to maintain present levels of production.

Sherritt Gordon Mines Limited announced in 1983 that its Fox copper-zinc mine would be mined out by early 1986. At its Ruttan mine, Sherritt mined higher-grade ore while it attempted to find an investor for a portion of the $25-30 million required to develop deeper higher-grade ore. When no agreement was reached, Sherritt announced that the mine would be closed in June 1984 but the Manitoba government agreed to contribute $10 million and the closure decision

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was rescinded. Mining of the deeper higher-grade ore planned for late 1985 should result in significant cost reductions.

Cominco Ltd. commenced production at the Lake Zone in the Highland Valley in British Columbia in January 1983, after acquiring ownership of the entire orebody. Staged expansions of the Lake Zone has been studied but low copper prices are preventing expansion. Highmont mine which ceased operations in October 1984 had remained in operation because of support prices paid by the purchasers of the concentrates. Afton Operating Corp. near Kamloops, resumed production in May 1983 but closed the smelter in August 1983 as concentrates sale became more economic. Esso Resources Canada Limited wrote down the book value of its Granduc mine by $40 million in January 1983 and closed the mine in April 1984 due to low copper prices. At the Island Copper mine at Port Hardy on Vancouver Island, installation of an in-pit moveable crusher and conveying system to reduce operating costs is scheduled for completion in early 1985. Westmin Resources Limited continued development of its HW project on Vancouver Island. The $225 million project had been delayed by a 4½ month strike and is now expected to be completed in early 1985. Brenda Mines Ltd. shut down at the end of September 1983 due to low copper and molybdenum prices, then operated from late May to mid-December 1984. Mine management at Brenda was quoted as saying that a price of between 75-80¢ (U.S.)/lb of copper and $US 4/lb for molybdenum would be required for the mine to reopen. Falconbridge mined out its Wesfrob iron-copper mine at Tasu on the Queen Charlotte Islands.

Gibraltar Mines Limited completed milling its low-grade ore stockpile in 1983. Mining recommenced following a replanning of the operations which permitted operation with a reduced waste to ore ratio. Noranda's Goldstream mine shut down in April 1984.

### Smelting and Refining

As the Division Mines Gaspé mines were shut in 1983, the smelter had difficulty in obtaining sufficient concentrates. When the smelter at KCML Inc. (formerly Kidd Creek Mines Ltd.) was rebricked in 1983, concentrates were directed to Gaspé for treatment. These, plus imported concentrates permitted the Gaspé smelter to operate continuously throughout the second half of 1983 to May 1984. In December 1984, the Gaspé smelter reopened with a concentrates inventory sufficient to permit operation until May 1985. In 1984, the Quebec government announced intended legislation to reduce sulphur dioxide emissions from Noranda's Horne smelter by the end of 1988: Noranda stated that this could force the closure of the Horne smelter. Noranda's CCR Division's refinery which produced 176 900 t of refined copper in 1983 cut its operating rate by 25 per cent due to reduced blister supplies. KCML's Mitsubishi continuous reactor smelter operated at its rated capacity of 59 000 tpy of copper in 1983. In July 1984, KCML announced that it would spend $54 million to increase the capacity of the copper smelter and refinery to 90 000 tpy of copper by 1988.

The "custom" copper smelters in Canada continued to face difficult market circumstances. The Gaspé, Horne and Flin Flon smelters were originally built to treat concentrates from adjacent large mines. However, now that these orebodies are either exhausted or closed or unable to supply sufficient feed, the smelters must attempt to obtain concentrates from more distance sources. Well situated for their original purpose, these smelters are now poorly located to obtain concentrates at economic rates due to transportation costs. The world-wide shortage of concentrates has further exacerbated their problems by driving down smelting and refining charges as too much smelter and refinery capacity competes for concentrates. The need to control sulphur dioxide emissions will further erode the viability of these smelters.

### Government Initiatives

Energy, Mines and Resources with assistance from industry, the provinces, labor and other departments completed a special report entitled "Canada's Nonferrous Metals Industry: Nickel and Copper" which was released in May 1984. The study's objective was "to identify the elements of a Canadian strategy which would foster an internationally viable and growing nonferrous metals industry, consistent with long standing economic development and environmental goals". The study examined the implications associated with reductions in sulphur dioxide emissions, at a time when metals markets are weak.

The Quebec government provided financial grants and loans forgiveable under certain circumstances to a wide range of the mineral industry. Copper deposits which will benefit from the program include Ansil, the E zone at Murdochville, and BP's A-1 zone.

## WORLD DEVELOPMENTS

Copper producers in the western world reacted to the sustained low prices in 1983 and 1984 by reducing costs through changed work practices, mining and processing techniques, engineering, operational control, and labour productivity. While demand grew from 1983 to 1984 and much of the overhanging inventory was drawn down, copper prices remained very low as consumers perceived future price reductions and no supply problems.

In the western world, mine production of copper was 6.18 million t in 1983 and was estimated at 6.35 million t in 1984, refined production was 7.32 million t and was estimated at 7.26 million t in 1984, and consumption was 6.77 million t in 1983 and was estimated at 7.20 million t in 1984.

Chile became the leading producer in the western world. The People's Republic of China imported 485 000 t in 1983 over four times the average annual imports for 1979-82. Chinese imports in 1984 are expected to remain very high.

**United States** producers mine low grade deposits by world standards and thus they were hard hit by the low metal prices in 1983 and 1984. United States mine production of copper was 1.038 million t in 1983 and was estimated at 1.1 million t in 1984, compared to 1.538 million t in 1981. U.S. refined copper production was estimated at 1.5 million t in 1984 compared to 1.58 million t in 1983. As the economic recovery commenced in the United States, refined copper consumption increased from 1.664 million t in 1982 to 1.767 million t in 1983 to 2.1 million t in 1984. Domestic U.S. producers' concern with respect to increased imports, primarily from Chile, resulted in a petition for relief under section 201 of the U.S. Trade Act. The intent was to limit imports to increase U.S. prices so that U.S. producers could reopen. The petition was opposed by producers from Canada and from other major producing companies and governments, and by various U.S. copper fabricators who feared that their competitive positions would be threatened despite a tariff on wrought copper. Two commissioners' recommendations were for a 5¢ (U.S.)/lb tariff, two were for quotas and the fifth did not recommend relief. In September, President Reagan chose not to impose quotas or tariffs. About 500 000 tpy of copper mine capacity was shut down in the United States at the end of 1984.

Anamax Mining Company suspended mining operations at its Twin Butte mine at the end of January 1983. The mill will continue to process oxides at a rate of 13 600 tpy of contained copper in 1985. Atlantic Richfield Co. intends to sell its Anaconda Minerals Company copper assets. ASARCO Incorporated completed the rebuilding of its 160 000 tpy Hayden smelter in mid-1984, and in June 1984 announced that its Tacoma smelter would shut by mid-1985 due to large projected expenses to comply with environmental regulations and also due to concentrate shortages. The 105 000 tpy smelter was one of the few in the world which could treat concentrates with high levels of impurities. The company also shut down its Silver Bell Copper Mine in August 1984 where costs of 72¢ (U.S.)/lb for the first half of 1984, were reported. Pennzoil Corporation announced in November 1984 that it would sell the copper operations of its subsidiary, Duval Corporation. At the time, Duval's only operating copper property was the Sierita mine. Inspiration Resources Corporation spent $US 101 million to modernize its 100 000 tpy smelter at Miami, Arizona to meet environmental regulations. It was estimated that total environmental expenditures could reach $US 158 million by the end of 1986. Kennecott Corporation cut production at its 180 000 tpy Utah division to 53 500 tpy in July 1984. Decision about a $US 1 billion program to modernize the Utah division is expected by early 1985. The 100 000 tpy Inco flash furnace was completed in October 1984 at Chino Copper Mines. Phelps Dodge Corporation continued operations in 1983-84 although the union called a strike, in July 1983. Prior to the strike the average miner at Phelps Dodge had been receiving wages of $US 26,000/year and $US 10,500/year in benefits.

**Chile** became the world's largest copper producer in 1983. Production was 1.038 million t in 1983 and was estimated at 1.07 million t in 1984. Chile is the world's largest exporter of refined copper and third largest exporter of copper in concentrates. Due to lower than forecast copper prices, the government devalued the peso from 93 per U.S. dollar to 115 per U.S. dollar in September 1984 (Chilean inflation was 8.7

per cent for the first eight months of 1984). Chile earned about half of its foreign exchange by copper exports in 1983. The Corporacion Nacional del Cobre de Chile (Codelco), a state-owned corporation, produced 1.012 million t of copper in 1983 and estimated production for 1984 was 1.046 million t. Income before taxes in 1983 was $US 528 million. Present plans call for Codelco production of 1.35 million tpy by the late 1980s. Official investment plans for 1984-86 total $US 1,418 million, with at least a further $US 673 million required after 1986. Part of the investment ($US 268 million) will be financed by an Inter-American Development Bank Loan. Expansions are intended to offset grade declines, normal at most mining operations. Codelco intends to meet new demand for copper by expansions of Chilean production. Possible development of the La Escondida copper deposit in northern Chile was delayed by low copper prices, and by the sale of 50 per cent of the ownership (when BHP acquired Utah from General Electric Company). The owner of the other 50 per cent, Texaco Inc. also wishes to sell its mineral subsidiary. Development will likely be delayed until the new owners study their decisions to commit about $US 750 million each for the 380 million t deposit averaging 1.92 per cent copper. Thus, production may not proceed before 1990 or 1992.

**Zaire's** two copper producers, Gécamines and Sodimiza, produced 466 600 t and 40 000 t of copper respectively in 1983. Production in 1984 was expected to be equivalent to 1983 levels. Copper plus cobalt accounted for 47 per cent of Zairean exports in 1982. Gécamines plans to obtain loans for a third of the $US 750 million required for a five year program to reduce costs and increase productivity. A partially completed refinery may be finished which would decrease the present 240 000 tpy of blister exported (200 000 t of which is refined in Belgium). Management of Sodimiza, originally financed and managed by Japanese interests, was contracted out by Zaire in 1984 to Phillips Barat Kaiser Engineering Ltd. of Vancouver. Sodimiza concentrates which had been shipped to Japan are now sold to Motors Trading Corporation and smelted in Zambia.

**Zambia's** state-owned Zambia Consolidated Copper Corporation (ZCCM) produced 551 000 t of copper in the financial year 1983/84, down 245 000 t from a year earlier. Zambia arranged financing for ZCCM in excess of $US 500 million from the World Bank, the Africa Development Bank and the European Economic Community (EEC).

In **Portugal,** Rio Tinto Zinc Corporation Limited made an offer to acquire French interests in the Neves-Corvo deposit. The state-owned company which holds 51 per cent of the interest has first right of refusal on the 49 per cent interest being sold. The first orebody is 27 million t of 8.66 per cent copper. By 1987, 1 million tpy of ore will be mined producing over 70 000 tpy copper in concentrates.

In **Peru,** the Tintaya project is expected to start up in early 1985 producing 55 000 tpy of Cu in concentrates. Southern Peru Copper Corporation decided not to expand the Cuajone mine.

**Australia's** largest copper producer is Mount Isa Mines. Due to low copper prices, expenditures were cut and development of deeper ore will be delayed a year. At the Olympic Dam project, the feasibility of mining 1.25 million tpy in the late 1980s then 5 million tpy in the mid-1990s was studied. A bulk sample was shipped to Finland for flash smelting tests.

In the **Philippines,** the $US 380 million Pasar copper smelter and refinery complex was opened in July 1983. Due to low smelting and refining charges outside of the Philippines, the government used export control legislation to force some mines to supply feed to Pasar. Copper smelting charges were reduced by 5.9¢ (U.S.)/lb at the end of 1984. Expansion beyond 138 000 tpy is unlikely to be economic in the medium-term.

**Japan's** custom smelters and refineries reduced production due to shortages of concentrates. Forecasts for fiscal 1984/85 (and actual for fiscal 1983/84) are: refined production 0.932 million t (1.05 million t), domestic demand 1.48 million t (1.41 million t), refined imports 0.414 million t (0.267 million t) and refined exports 0.020 million t (0.132 million t). A significant proportion of Japanese output is believed to be exported to China as semi-manufactured items.

**China** purchased 486 000 t of copper in all forms in 1983. Purchases were estimated at 375 000 t for 1984. A 90 000 tpy smelter completed in 1983 in Guixi province remained idle due to low copper prices.

In **Papua, New Guinea,** development of the copper portion of the Ok Tedi mine, already delayed to 1987, may be put back to 1989.

## STOCKS

London Metal Exchange (LME) total copper stocks rose from the start of 1983 almost uninterruptedly by over 70 per cent to just over 435 000 t at the end of 1983. Then total stocks decreased rapidly to 126 375 t at the end of 1984 while higher grade stocks went from 118 575 t to 49 400 t. Comex stocks rose from 249 000 t at the start of 1983 to 371 000 t at the start of 1984 and decreased to 277 009 t at the end of 1984. Comex plus LME stocks decreased from 806 900 t to 403 384 t during 1984. Total non-socialist world stocks at the end of October 1984 were reported at 1.65 million t compared to 2.06 million t at the end of 1983.

The LME was asked to establish a separate contract for copper wirebars, as higher-grade cathodes are increasingly favoured by purchasers. It was argued that allowing delivery of wirebars (when the purchaser probably wishes cathodes) acts to depress the price of the higher-grade cathode contract. Thus a separate contract for wirebars would likely result in lower prices for wirebars compared to higher-grade cathodes. Opposition was expressed by wirebar producers who feared a loss in revenue and no changes were made in 1984. In October, the LME fire refined contract was eliminated.

The basic copper grade for COMEX was changed to Grade 2 Electrolytic for December 1985 contracts and thereafter. Wirebars, which used to command a premium, will trade at par with the basic contract. Grade 1 electrolytic copper will command a ½¢ (U.S.)/lb premium (£ 9/t at the exchange rate prevailing when announced).

## PRICES

The variations in copper prices depended upon the currency used. Fourth quarter LME prices in sterling recovered nearly to mid-1983 levels of over £ 1 100/t whereas prices in U.S. currency in the range of 57-61¢ (U.S.)/lb in December 1984 were far below the 77-79¢ (U.S.)/lb range of mid-1983. Average price for LME copper higher grade cash was 72.1¢ (U.S.)/lb in 1983 and 62.4¢ (U.S.)/lb in 1984. Historical and deflated copper prices from 1970 to 1984 are shown graphically.

## OUTLOOK

Consumption is expected to increase at an average of 1.2 per cent per year in the 1980s from a 1981 base and at an average of 1.6 per cent per year in the 1990s. While no major new uses for copper have been identified, substitution away from copper in the future is expected to occur at lower rates than those in the past. Current applications of copper will continue to be the major end use. As funding is inadequate to support significant market research and development to promote new uses of copper, substitution away from copper will continue. In the short-term, western world consumption is forecast at 7.35 to 7.40 million t in 1985. In the long-term, western world copper refined consumption is forecast at 7.9 million t in 1990 and 9.2 million t in 2000. China is expected to continue to import about 375 000 tpy of copper in the short-term.

Existing mine, smelter and refinery capacity will be able to meet the projected short-term demand without requiring any new greenfields projects. Producers have increased productivity to reduce costs in the face of low prices and have expanded production where possible to lower unit costs. Mine production is expected to increase in Chile and Peru in the short-term and decrease to 900 000 t in the United States.

In the medium-term, incremental expansions are expected to meet all of the increases in demand and to compensate for permanent closures. The only greenfield project expected to be producing before 1990 is Neves-Corro in Portugal. However by the early 1990s, the producers who have reduced stripping ratios and restricted development in the 1980s in order to minimize financial loses are not expected to be able to maintain output. Thus in the early 1990s, new greenfields projects are likely to be required. The first projects to be completed would likely include the full scale Olympic Dam project in Australia, La Escondida in Chile, and Valley Copper in Canada.

Most copper producers, with the exception of Codelco, continued to lose money in 1984 or to generate very low profits. The copper production capacity completed in the 1970s when real rates of interest were low was built to fulfil a demand growth of 4 per cent per year which never materialized. The majority of the price-sensitive, high cost producers have closed, but many have been kept in a state allowing for rapid reopening if prices were to increase. As long as these mines can reopen, there is a barrier to sustained high prices. In the short-term, a price over 75¢ (U.S.)/lb would allow significant production to be restarted. Hence an average price of 68¢ (U.S.)/lb is predicted for 1985. Localized supply problems and general inventory drawdowns are likely to increase prices in the first half of 1985 above the forecast average price for the year. Premiums for higher-grade materials are likely to rise at that time. A price of 75¢ (U.S.)/lb in 1985 U.S. dollars is forecast for 1986. By 1990 as closures have become permanent and opportunities for incremental expansions have been exhausted the price in 1985 U.S. dollars should trend through a value of 88-92¢ (U.S.)/lb. Thereafter, a price rise in the 1990s above a level of 88-92¢ (U.S.)/lb in 1985 U.S. dollars is not expected to be sustainable due to technological advances in the mineral industry and increased substitution due to price. Historical average prices of approximately $US 1.25/lb (1985 dollars) are not expected to be sustainable.

Due to the oversupply of smelting and refining capacity, smelting and refining charges in 1985 and 1986 are forecast at 15-17¢ (U.S.)/lb for medium-term contracts. Spot prices will remain very low. Possible new smelting and refinery capacity in Chile, Brazil, Zaire, Australia and Portugal are expected to keep charges low.

In **Canada**, the industry joined the rest of the price-sensitive market economy producers by reducing operating costs in response to low metal prices. For example, at the two major nickel producers (who produced 15 per cent of Canada's copper in 1983 despite a shutdown by Inco) some of the mines have reduced production costs by 25 per cent in one year. In order to coordinate research and development directed at lowering costs and to best employ Canadian expertise, Inco, Noranda, KCML and Falconbridge formed a company to jointly fund research and development to improve productivity. Another company owned by Inco develops and manufactures hard rock mining equipment.

Between 1981 and 1983, the international competitive position of the Canadian copper industry weakened, partly due to very significant currency devaluations by major competitors. While some of those devaluations may have been overdue based on balance of payments considerations, these devaluations were responsible for much of the deterioration in the Canadian competitive position. However, currency devaluations are followed by inflation which later negate the competitive advantages afforded by devaluation. Devaluations also impose social strains on some economies which can lead to political resistance to further devaluations. Thus Canadian producers who have kept in operation, while unable to avail themselves of relief from low prices through large currency devaluations and who have been able to make significant cost reductions, should move back towards their more traditional competitive positions as inflation increases the costs of their competitors.

**TARIFFS**

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| CANADA | | | (%) | | |
| 32900-1 | Copper in ores and conc. | free | free | free | free |
| 33503-1 | Copper oxides | free | 13.8 | 25.0 | free |
| 34800-1 | Copper scrap, matte and blister and copper in pigs, blocks or ingots; cathode plates of electrolytic copper for melting, per lb | free | free | 1.5¢ | free |
| 34820-1 | Copper in bars or rods, when imported by manufacturers of trolley, telegraph and telephone wires, and electric wires and electric cables, for use only in the manufacture of such articles in their own factories | free | 4.5 | 10.0 | free |
| 34835-1 | Electrolytic copper powder electrolytic iron powder, for use in Canadian manufactures (expires June 30, 1983) | free | free | 10.0 | free |
| 34845-1 | Electrolytic copper wire bars, for use in Canadian manufactures per lb (expires June 30, 1983) | free | free | 1.5¢ | free |
| 35800-1 | Anodes of copper | free | free | 10.0 | free |

| MFN Reductions under GATT (effective January 1 year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 33503-1 | 13.8 | 13.4 | 13.1 | 12.8 | 12.5 |
| 34820-1 | 4.5 | 4.4 | 4.3 | 4.1 | 4.0 |
| UNITED STATES (MFN) | | | | | |
| 602.30 Copper, ores etc. | Remains free | | | | |
| 612.02 Unwrought copper, etc. | - no change - | | | | 1.7 |
| 612.08 Copper waste and scrap | 4.2 | 3.8 | 3.3 | 2.9 | 2.4 |

| Item No. | | 1983 | Base Rate | Concession Rate |
|---|---|---|---|---|
| EUROPEAN ECONOMIC COMMUNITY (MFN) | | | | |
| 26.01 | Copper, ores and conc. | free | free | free |
| 74.01 | Copper in matte, unwrought copper, waste and scrap | free | free | free |
| JAPAN (MFN) | | | | |
| 26.01 | Copper, ores and conc. | free | free | free |
| 74.01 | (1) Copper in matte etc. | free | free | free |
| | (2) Copper, unwrought | | | |
| | (a) containing not more than 99.8% by weight of copper etc. | 7.9% | 8.5% | 7.3% |
| | (b) Other | | | |
| | (i) Containing by weight, not less than 25% of zinc and not less than 1% of lead | 19.50yen/kg | 24yen/kg | 15yen/kg |
| | (ii) Containing more than 95% by weight of copper | | | |
| | - blister copper in bar | 7.9% | 8.5% | 7.3% |
| | - other | 22.50yen/kg | 24yen/kg | 21yen/kg |
| | (iii) Containing not more than 95% by weight of copper | 22.50yen/kg | 24yen/kg | 21yen/kg |
| | (3) Waste and scrap | | | |
| | (a) Unalloyed | 1.3% | 2.5% | free |
| | (b) Other: containing more than 10% by weight of nickel | 11.3% | 22.5% | free |
| | (c) Other | 1.3% | 2.5% | free |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1983), USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 25, No. L318, 1982; Customs Tariff Schedules of Japan, 1983; GATT Documents, 1979.

TABLE 1. CANADA, COPPER PRODUCTION, TRADE AND CONSUMPTION, 1982-84

| | 1982 | | 1983r | | 1984e | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Shipments**[1] | | | | | | |
| British Columbia | 280 969 | 548,256 | 282 754 | 597,710 | 288 646 | 547,561 |
| Ontario | 158 220 | 308,735 | 219 803 | 412,140 | 291 107 | 552,231 |
| Quebec | 94 977 | 185,329 | 63 740 | 132,352 | 62 713 | 118,967 |
| Manitoba | 48 810 | 95,243 | 67 163 | 132,008 | 57 642 | 109,347 |
| New Brunswick | 13 125 | 25,610 | 11 369 | 19,037 | 7 185 | 13,631 |
| Saskatchewan | 4 898 | 9,557 | 6 204 | 13,676 | 4 252 | 8,066 |
| Newfoundland | 3 731 | 7,280 | - | 384 | 749 | 1,421 |
| Yukon | 7 510 | 14,654 | 1 904 | - | - | - |
| Northwest Territories | 215 | 419 | 102 | - | 79 | 149 |
| Total | 612 455 | 1,195,083 | 653 040 | 1,307,307 | 712 374 | 1,351,373 |
| **Refinery output** | 337 780 | .. | 464 333 | .. | 515 000 | |
| | | | | | (9 months export data) | |
| **Exports** | | | | | | |
| Copper in ores, concentrates and matte | | | | | | |
| Japan | 182 916 | 236,366 | 212 094 | 270,931 | 165 095 | 210,331 |
| South Korea | 14 882 | 17,427 | 38 716 | 39,898 | 25 479 | 28,857 |
| Taiwan | 5 672 | 6,658 | 23 761 | 35,151 | 1 405 | 1,826 |
| Norway | 15 018 | 21,523 | 18 216 | 27,818 | 20 229 | 30,140 |
| United States | 19 508 | 21,602 | 12 255 | 17,608 | 14 956 | 19,203 |
| People's Republic of China | - | - | 2 516 | 4,064 | 18 837 | 26,285 |
| Mexico | - | - | 1 713 | 2,572 | - | - |
| United Kingdom | 747 | 567 | 1 775 | 2,538 | 611 | 1,172 |
| Belgium-Luxembourg | 1 984 | 2,691 | 1 900 | 2,141 | 246 | 145 |
| Other countries | 17 203 | 23,844 | 850 | 882 | 2 396 | 3,075 |
| Total | 257 930 | 330,678 | 313 796 | 403,603 | 249 252 | 321,034 |
| Copper in slag, skimmings and sludge | | | | | | |
| United States | 1 105 | 215 | 1 708 | 753 | 2 488 | 1,051 |
| Spain | 247 | 228 | - | - | - | - |
| United Kingdom | 4 | 13 | - | - | - | - |
| Total | 1 356 | 456 | 1 708 | 753 | 2 488 | 1,051 |
| Copper scrap (gross weight) | | | | | | |
| United States | 21 613 | 30,089 | 31 939 | 42,123 | 21 351 | 32,669 |
| Japan | 4 788 | 5,705 | 2 385 | 3,242 | * | * |
| South Korea | 1 400 | 1,996 | 510 | 797 | * | * |
| Sweden | - | - | 279 | 507 | - | - |
| Taiwan | 49 | 65 | 370 | 443 | * | * |
| Belgium-Luxembourg | 649 | 703 | 239 | 368 | * | * |
| Spain | 1 675 | 2,203 | 181 | 259 | * | * |
| Other countries | 1 013 | 1,236 | 203 | 298 | 2 565 | 3,839 |
| Total | 31 187 | 41,997 | 36 106 | 48,037 | 23 916 | 36,508 |
| Brass and bronze scrap (gross weight) | | | | | | |
| United States | 6 948 | 8,370 | 11 870 | 16,557 | 8 947 | 12,224 |
| Belgium-Luxembourg | 2 951 | 3,710 | 694 | 881 | * | * |
| Taiwan | 214 | 255 | 727 | 829 | * | * |
| West Germany | 949 | 1,335 | 332 | 534 | * | * |
| India | 2 224 | 2,645 | 292 | 335 | * | * |
| Japan | 452 | 582 | 241 | 316 | * | * |
| South Korea | 596 | 741 | 155 | 244 | * | * |
| Netherlands | 88 | 93 | 88 | 137 | * | * |
| Other countries | 958 | 1,124 | 139 | 155 | 2 849 | 3,642 |
| Total | 15 380 | 18,855 | 14 538 | 19,988 | 11 796 | 15,866 |

**TABLE 1.** (cont'd.)

| | 1982 | | 1983P | | 1984 | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| | | | | | (9 months export data) | |
| Copper alloy scrap, nes (gross weight) | | | | | | |
| United States | 3 037 | 3,031 | 2 094 | 2,473 | 3 178 | 3,800 |
| Belgium-Luxembourg | 1 079 | 1,348 | 222 | 268 | * | * |
| South Korea | 375 | 445 | 149 | 188 | * | * |
| West Germany | 88 | 138 | 40 | 97 | * | * |
| Taiwan | 207 | 84 | 93 | 46 | * | * |
| Japan | 19 | 22 | 18 | 29 | * | * |
| Other countries | 68 | 55 | 21 | 53 | 456 | 611 |
| Total | 4 873 | 5,123 | 2 637 | 3,154 | 3 643 | 4,411 |
| Copper refinery shapes | | | | | | |
| United States | 93 219 | 170,781 | 93 138 | 190,264 | 147 642 | 277,311 |
| People's Republic of China | - | - | 67 137 | 135,242 | 12 556 | 22,014 |
| United Kingdom | 65 881 | 132,659 | 46 444 | 91,697 | 29 799 | 55,724 |
| Netherlands | 9 040 | 17,302 | 35 075 | 71,784 | 15 268 | 27,798 |
| West Germany | 22 194 | 42,291 | 24 496 | 49,494 | 18 652 | 33,755 |
| France | 10 741 | 20,573 | 13 204 | 25,842 | 10 182 | 18,403 |
| Sweden | 9 578 | 18,391 | 6 261 | 12,229 | 8 188 | 15 031 |
| Belgium-Luxembourg | 14 594 | 32,907 | 4 429 | 7,362 | 18 | 38 |
| Italy | 4 129 | 7,990 | 3 299 | 6,353 | 3 104 | 5,634 |
| Japan | 3 | 6 | 2 946 | 3,317 | 2 004 | 3,664 |
| South Korea | 293 | 631 | - | - | 3 996 | 7,282 |
| Taiwan | 83 | 50 | - | - | 3 007 | 5,177 |
| Other countries | 1 394 | 2,661 | 181 | 363 | 811 | 1,729 |
| Total | 232 621 | 448,992 | 298 528 | 599,698 | 255 297 | 473,560 |
| Copper bars, rods and shapes, nes | | | | | | |
| United States | 8 084 | 16,571 | 5 531 | 14,396 | 7 814 | 19,394 |
| Venezuela | 1 451 | 3,356 | 1 574 | 3,556 | 1 975 | 4,181 |
| Dominican Republic | 416 | 881 | 826 | 1,986 | * | * |
| Saudi Arabia | - | - | - | - | 2 057 | 3,927 |
| Ireland | - | - | 397 | 860 | * | * |
| Bangladesh | 567 | 1,188 | 285 | 588 | 2 196 | 4,145 |
| India | - | - | - | - | 1 800 | 3,260 |
| Other countries | 1 678 | 3,808 | 194 | 430 | 1 847 | 3,868 |
| Total | 12 327 | 26,084 | 9 435 | 23,144 | 17 689 | 38,775 |
| Copper plates, sheet and flat products | | | | | | |
| United States | 3 707 | 11,612 | 3 473 | 11,253 | 4 497 | 14,392 |
| United Kingdom | 125 | 404 | 162 | 602 | * | * |
| Israel | - | - | 89 | 236 | * | * |
| West Germany | - | - | 44 | 145 | * | * |
| Venezuela | 50 | 202 | 29 | 115 | * | * |
| Other countries | 27 | 94 | 30 | 101 | 149 | 515 |
| Total | 3 909 | 12,312 | 3 827 | 12,452 | 4 646 | 14,907 |
| Copper pipe and tubing | | | | | | |
| United States | 2 327 | 7,288 | 3 685 | 10,832 | 3 633 | 10,781 |
| Israel | 826 | 2,238 | 1 073 | 2,905 | 897 | 2,381 |
| West Germany | 1 058 | 2,600 | 553 | 1,520 | * | * |
| United Kingdom | 536 | 1,634 | 245 | 992 | * | * |
| Netherland Antilles | 5 | 18 | 98 | 291 | * | * |
| South Africa | 1 | 5 | 26 | 85 | * | * |
| Mexico | - | - | 18 | 74 | - | - |
| Saudi Arabia | 38 | 146 | 31 | 48 | - | - |
| Netherlands | 5 | 19 | 3 | 12 | - | - |
| Spain | - | - | 2 | 11 | - | - |
| Other countries | 46 | 167 | 38 | 139 | 529 | 1,538 |
| Total | 4 842 | 14,115 | 5 772 | 16,909 | 5 059 | 14,700 |
| Copper wire and cable (not insulated) | | | | | | |
| United States | 100 | 350 | 539 | 1,129 | 455 | 933 |
| Saudi Arabia | 38 | 125 | 122 | 376 | - | - |
| Puerto Rico | - | - | 128 | 344 | - | - |
| New Zealand | 5 | 29 | 54 | 113 | - | - |
| Other countries | 39 | 102 | 47 | 181 | 142 | 391 |
| Total | 182 | 606 | 890 | 2,143 | 597 | 1,324 |

TABLE 1. (cont'd.)

| | 1982 | | 1983P | | 1984 | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| | | | | | (9 months export data) | |
| Copper alloy shapes and sections | | | | | | |
| United States | 7 873 | 24,264 | 12 376 | 35,858 | 14 102 | 40,650 |
| United Kingdom | 71 | 230 | 36 | 126 | | |
| Venezuela | 24 | 81 | 19 | 71 | | |
| West Germany | | 1 | 15 | 42 | | |
| Other countries | 117 | 252 | 9 | 56 | 70 | 225 |
| Total | 8 085 | 24,828 | 12 455 | 36,153 | 14 172 | 40,875 |
| Copper alloy pipe and tubing | | | | | | |
| United States | 1 616 | 6,038 | 4 630 | 12,564 | 4 047 | 11,580 |
| West Germany | | | 56 | 166 | * | * |
| Bangladesh | | | 18 | 87 | | |
| United Kingdom | | 6 | 16 | 63 | | |
| Other countries | 42 | 170 | 12 | 41 | 40 | 112 |
| Total | 1 658 | 6,214 | 4 732 | 12,921 | 4 087 | 11,692 |
| Copper alloy wire and cable, not insulated | | | | | | |
| United States | 102 | 529 | 104 | 292 | 286 | 660 |
| South Africa | 18 | 156 | 43 | 222 | * | * |
| New Zealand | 17 | 113 | 17 | 103 | * | * |
| Chile | 10 | 70 | 11 | 68 | | |
| Other countries | 5 | 37 | 17 | 54 | 29 | 195 |
| Total | 152 | 905 | 192 | 739 | 315 | 4,855 |
| Copper and alloy fabricated materials, nes | | | | | | |
| United States | 698 | 3,143 | 1 337 | 4,555 | 1 518 | 4,890 |
| United Kingdom | 13 | 186 | 132 | 319 | * | * |
| Taiwan | 29 | 311 | 39 | 521 | * | * |
| Mexico | | | 16 | 86 | | |
| Other countries | 66 | 511 | 40 | 224 | 488 | 1,094 |
| Total | 806 | 4,041 | 1 564 | 5,705 | 1 966 | 5,984 |
| Insulated wire and cable[2] | | | | | | |
| United States | 14 315 | 54,717 | 24 324 | 83,689 | 21 434 | 84,792 |
| Saudi Arabia | 7 805 | 24,736 | 3 196 | 10,397 | * | * |
| Trinidad Tobago | 324 | 1,063 | 1 805 | 6,098 | 1 700 | 5,423 |
| Puerto Rico | 157 | 528 | 812 | 2,520 | 1 845 | 5,718 |
| Panama | 206 | 574 | 134 | 1,493 | * | * |
| Singapore | 660 | 2,408 | 366 | 1,300 | * | * |
| Libya | 31 | 135 | 406 | 1,138 | * | * |
| Egyptian A.R. | 1 201 | 4,789 | 317 | 1,100 | * | * |
| Indonesia | 108 | 450 | 261 | 907 | * | * |
| Pakistan | | | | | 2 990 | 9,082 |
| Other countries | 3 224 | 14,571 | 1 534 | 6,888 | 3 492 | 16,774 |
| Total | 28 121 | 103,418 | 33 302 | 116,338 | 34 461 | 121,789 |
| Total exports of copper and products | .. | 1,038,674 | .. | 1,301,737 | | |
| | | | | | (9 month import data) | |
| **Imports** | | | | | | |
| Copper in ores and concentrates | 12 362 | 13,742 | 24 535 | 39,984 | 30 024 | 28,592 |
| Copper scrap | 33 230 | 34,553 | 64 363 | 68,206 | 48 966 | 55,444 |
| Copper refinery shapes | 28 028 | 52,760 | 24 559 | 56,126 | 21 453 | 40,979 |
| Copper bars, rods and shapes, nes | 6 061 | 12,406 | 9 626 | 21,508 | 3 829 | 8,436 |
| Copper plates, sheet strip and flat products | 977 | 3,534 | 1 370 | 4,615 | 3 587 | 10,403 |
| Copper pipe and tubing | 2 519 | 9,170 | 3 479 | 12,022 | 2 162 | 7,844 |
| Copper wire and cable, not insulated | 1 952 | 5,202 | 1 822 | 7,023 | 2 263 | 8,585 |
| Copper alloy scrap (gross weight) | 7 883 | 8,266 | 2 104 | 7,521 | 2 722 | 8,341 |
| Copper powder | 540 | 1,245 | 827 | 1,846 | 1 005 | 2,316 |
| Copper alloy refinery shapes, bars and sections | 6 742 | 16,449 | 9 835 | 23,695 | 9 410 | 23,829 |
| Brass plates, sheet and flat products | 2 767 | 8,663 | 3 542 | 11,060 | 3 348 | 10,221 |

TABLE 1. (cont'd.)

| | 1982 | | 1983P | | 1984 | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| | | | | | (9 months export data) | |
| **Imports** (cont'd) | | | | | | |
| Copper alloy plates, sheets, strip and flat products | 773 | 4,332 | 1 673 | 7,733 | 1 336 | 6,111 |
| Copper alloy pipe and tubing | 1 884 | 8,978 | 2 851 | 12,859 | 3 171 | 11,654 |
| Copper alloy wire and cable, not insulated | 774 | 2,837 | 1 194 | 3,969 | 951 | 3,313 |
| Copper and alloy fabricated material, nes | 2 486 | 11,814 | 1 849 | 10,272 | 1 576 | 8,661 |
| Insulated wire and cable | .. | 133,634 | .. | 61,873 | .. | 134,765 |
| Copper oxides and hydroxides | 288 | 767 | 201 | 543 | 183 | 467 |
| Copper sulphate | 1 536 | 2,751 | 873 | 638 | 2 029 | 1,354 |
| Copper alloy castings | 228 | 1,335 | 503 | 3,416 | 593 | 3,758 |
| Total imports of copper and products | .. | 333,061 | .. | 354,914 | | 358,076 |
| | | | | | (estimated | consumption) |
| **Consumption**³ | | | | | | |
| Refined | 130 559 | .. | 170 443 | .. | 190 000 | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
¹ Blister copper plus recoverable copper in matte and concentrate exported; totals may not add due to independent rounding. ² Includes small quantities of non-copper wire and cable, insulated. ³ Producers' domestic shipments, refined copper.
- Nil; .. Not available or not applicable; nes Not elsewhere specified; ʳ Revised; ᵉ Estimated; - Amount too small to be expressed.
* Minor amounts, included in other countries total; for complete details, refer to Statistics Canada Monthly Catalogue 65-004.

## TABLE 2. CANADA, COPPER PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975 AND 1980-84

| | Production | | | Exports | | Imports | Consumption² |
|---|---|---|---|---|---|---|---|
| | Shipments¹ | Refinery Output | Ore and Matte | Refined | Total | Refined | Refined |
| | | | | (tonnes) | | | |
| 1970 | 610 279 | 493 261 | 161 377 | 265 264 | 426 641 | 13 192 | 233 834 |
| 1975 | 733 826 | 529 197 | 314 518 | 320 705 | 635 223 | 10 908 | 185 198 |
| 1980 | 716 363 | 505 238 | 286 076 | 335 022 | 621 098 | 13 466 | 195 124 |
| 1981 | 691 328 | 476 655 | 276 810 | 262 642 | 539 452 | 21 778 | 216 759 |
| 1982 | 612 455 | 342 280 | 257 930 | 232 621 | 490 551 | 28 028 | 130 559 |
| 1983ʳ | 653 040 | 464 333 | 313 796 | 298 529 | 612 324 | 24 559 | 170 443 |
| 1984ᵉ | 712 374 | 515 090 | 249 252* | 255 297* | 504 549* | 21 154* | 190 000 |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
¹ Blister copper plus recoverable copper in matte and concentrate exported. ² Producers' domestic shipments of refined copper.
ʳ Revised; ᵉ Estimated; * Jan. to Sept. trade data for 1984.

## TABLE 3. CANADIAN COPPER AND COPPER-NICKEL SMELTERS, 1983

| Company and Location | Product | Rated Annual Capacity (tonnes of ores and concentrates) | Ore and Concentrates Treated (tonnes) | Blister or Anode Copper Produced (tonnes) | Remarks |
|---|---|---|---|---|---|
| Afton Operating Corporation<br>Kamloops, B.C. | Blister copper | 22 500 t of blister copper | .. | 3 100 | The smelter commenced commercial operation on May 1, 1978. The uniquely low-sulphur concentrate, consisting chiefly of native copper, was smelted in a top-blown rotary converter. $SO_2$ produced was neutralized with limestone. Smelter was closed permanently, August 1983. |
| Falconbridge Limited<br>Falconbridge, Ont. | Copper-nickel matte | 570 000 | .. | 27 500 | A smelter modernization program begun in 1975 was completed in 1978 at a cost of $79 million. Fluid bed roasters and electric furnaces replaced older smelting equipment. A 1 800 tpd sulphuric acid plant treats roaster gases. Matte from the smelter is refined in Norway. |
| Inco Limited<br>Sudbury, Ontario | Molten "blister" copper, nickel, sulphide and nickel sinter for the company's refineries; nickel oxide sinter for market, soluble nickel oxide for market | 3 630 000[1] | .. | 66 700[2] | Oxygen flash-smelting of copper concentrate; converters for production of blister copper. Roasters, reverberatory furnaces for smelting of nickel-copper concentrate, converters for production of nickel-copper Bessemer matte. Production of matte followed by matte treatment, flotation, separation of copper and nickel sulphides, then by sintering to make sintered-nickel products for refining and marketing. Electric furnace melting of copper sulphide and conversion to blister copper. |
| KCML Inc<br>Timmins, Ontario | Molten "blister" copper | 59 000 t of copper | 118 600 | 53 000 | Mitsubishi-type smelting, seperation and converting furnaces treat continuous copper concentrate feed stream to yield molten 99 per cent pure copper which is transported by ladles and overhead cranes to two 350 t anode furnaces. Furnaces rebricked in fall of 1983.<br>Expansion plans to 90 000 tpy announced in 1984. |

|  |  |  |  |  |
|---|---|---|---|---|
| Noranda Mines Limited, Horne smelter, Noranda, Que. | Copper anodes | 838 000 | 176 900 | Three reverberatory furnaces, one of which is now considered to be permanently shut down; 5 converters; 1 continuous reactor; an 85 tpd oxygen plant to supply oxygen-enriched blast. Continuous reactor modified to produce matte instead of metal. A $35 million project to overhaul and modify the smelter, with electricity to become the plant's major energy source was completed in 1982. The new 450 tpd oxygen plant will decrease unit fuel requirements and increase capacity of the continuous reactor, and reduce fuel requirements for a reverberatory furnace. |
| Noranda Mines Limited, Gaspé smelter, Murdochville, Que. | Copper anodes | 325 000 | 30 800 | Equipped with one fluid bed roaster, one reverberatory furnace and two converters plus an acid plant. Treats Gaspé and custom concentrates (mine at Gaspé shut throughout 1983). |
| Hudson Bay Mining and Smelting Co., Limited, Flin Flon, Man. | Copper anodes | 400 000 | 66 700 | Five roasting furnaces, one reverberatory furnace and three converters. Company treats its own copper concentrates from mines at Flin Flon, Snow Lake and Whitehorse, as well as custom copper concentrates, zinc plant residues and stockpiled zinc-plant residues fed to reverberatory furnace. |

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[1] Includes copper and nickel-copper concentrates. This capacity cannot all be fully utilized owing to Ontario government sulphur dioxide emission regulations. [2] A small portion of this copper was from Inco's Manitoba ores; operations at Sudbury restarted in April 1983 after a 10 month shutdown.
.. Not available.

**TABLE 4. COPPER REFINERIES IN CANADA, 1983**

| Company and Location | Rated Annual Capacity | Output in 1983 | Remarks |
|---|---|---|---|
| | (tonnes) | | |
| Noranda Mines Limited,<br>Division CCR,<br>Montreal East,<br>Quebec | 435 000 | 335 700 | Refines anodes from Noranda's Horne and Gaspé smelters and from the Flin Flon smelter; also purchased scrap. Copper sulphate and nickel sulphate recovered by vacuum evaporation. Precious metals, selenium and tellurium recovered from slimes. Produces C.C.R. brand electrolytic copper wirebars, ingot bars, ingots, cathodes, cakes and billets. |
| Inco Limited<br>Copper Refining Division<br>Copper Cliff, Ont. | 180 000 | 66 700 | Casts and refines anodes from molten converter copper from the Copper Cliff smelter; also refines purchased scrap. Gold, silver, selenium and tellurium recovered from anode slimes, along with platinum metals concentrates. Recovers and electrowins copper from Copper Cliff nickel refinery residue. Produces ORC brand electrolytic copper cathodes, and wirebars. |
| Kidd Creek Mines Ltd.<br>Timmins, Ontario | 59 000 | 53 000 | Molten copper from two 350 t anode furnaces is cast in a Hazelett continuous casting machine into continuous copper strip, then formed to 145 kg anodes in a blanking press. Spent and scrap anodes are remelted in a 40 t ASARCO shaft furnace. Cathodes formed in jumbo sized electrolytic tanks in a highly automated tankhouse. A decopperized precious metal slime is also marketed.<br>Expansion plans to 90 000 tpy by 1988 announced in 1984. |

### TABLE 5. WESTERN WORLD MINE PRODUCTION OF COPPER, 1983 AND 1984

| | 1983 | 1984e |
|---|---|---|
| | (000 tonnes) | |
| Chile | 1 257 | 1 290 |
| United States | 1 038 | 1 100 |
| Canada[1] | 654r | 712 |
| Zambia[2] | 515 | 455 |
| Zaire | 502 | 520 |
| Peru | 322 | 370 |
| Philippines | 271 | 230 |
| Mexico | 206 | 200 |
| South Africa | 212 | 200 |
| Other[3] | 1 205 | 1 273 |
| Total Western World[4] | 6 182 | 6 350 |

Sources: World Bureau of Metal Statistics, U.S. Bureau of Mines, and Energy, Mines and Resources Canada.

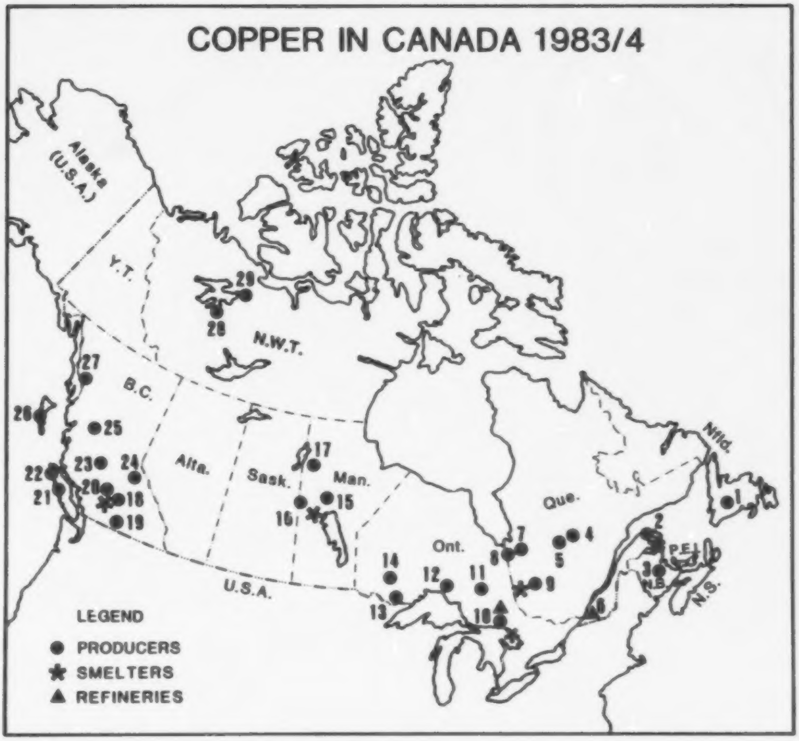
[1] Shipments. [2] Excludes electrowon copper. [3] Includes estimated 65 000 t increase in Iranian production from 1983 to 1984. [4] Includes Yugoslavia.
e Estimated; r Revised.

### TABLE 6. WESTERN WORLD REFINED PRODUCTION[1] OF COPPER, 1983 AND 1984

| | 1983 | 1984e |
|---|---|---|
| | (000 tonnes) | |
| United States | 1 580 | 1 500 |
| Japan | 1 090 | 930 |
| Chile | 833 | 850 |
| Zambia | 574 | 530 |
| Canada | 464 | 515 |
| Zaire | 227 | 220 |
| Peru | 190 | 245 |
| Australia | 200 | 200 |
| Other | 2 160 | 2 275 |
| Total Western World | 7 318 | 7 265 |

Sources: World Bureau of Metal Statistics, U.S. Bureau of Mines, and Energy, Mines and Resources Canada.

[1] Primary, secondary and electrowon copper.
e Estimated.



COPPER IN CANADA 1983/4

Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
LEGEND
● PRODUCERS
★ SMELTERS
▲ REFINERIES

## PRODUCERS IN 1983 or 1984

numbers correspond to those in map

1. ASARCO Incorporated (Buchans Unit)
2. Noranda Inc., Division Mines Gaspé (Needle Mountain)
3. Brunswick Mining and Smelting Corporation Limited (Nos. 6 and 12 mines)
   Heath Steele Mines Limited
4. Camchib Resources Inc. (Cedar Bay, Henderson and Merrill mines)
   Northgate Patino Mines Inc. (Copper Rand, Lemoine and Portage mines)
5. Corporation Falconbridge Copper, Opemiska Division (Perry, Springer and Cooke mines)
7. Noranda Mines Limited, Mattagami Division (Mattagami, Orchan, Norita mines)
8. B.P. Canada Inc., Les Mines Selbaie
9. Corporation Falconbridge Copper, Lake Dufault Division (Millenbach and Corbet mines)
   Louvem Mining Company Inc.
10. Falconbridge Limited (East, Falconbridge, Fraser, Lockerby, North and Strathcona mines)
    Inco Limited (Clarabelle, Coleman, Copper Cliff North, Copper Cliff South, Creighton, Frood, Garson, Levack, Little Stobie, Stobie, McCreedy West)
11. KCML Inc.
    Pamour Porcupine Mines, Limited (Schumacher, Ross mines)
12. Noranda Mines Limited, Geco Division
13. Inco Limited (Shebandowan mine)
14. Mattabi Mines Limited
    Noranda Mines Limited, Lyon Lake and F group mines
15. Inco Limited (Pipe No. 2 and Thompson mines)
16. Hudson Bay Mining and Smelting Co., Limited (Anderson, Centennial, Chisel, Flin Flon, Ghost, Osborne, Stall, Trout Lake Westarm and White Lake mines), Spruce Point
17. Sherritt Gordon Mines Limited Fox and Ruttan mines
18. Brenda Mines Ltd.
19. Newmont Mines Limited (Ingerbelle and Copper Mountain mines)
20. Cominco Limited (Valley Copper
    Lornex Mining Corporation Ltd.
    Afton Operating Corporation
    Highmont Operating Corporation
21. Westmin Resources Limited (Lynx, Myrna, Price and HW mines)
22. Utah Mines Ltd. (Island Copper mine)
23. Gibraltar Mines Limited
24. Noranda Mines Limited (Goldstream mine)
25. Equity Silver Mines Limited
26. Falconbridge Limited (Wesfrob mine)
27. Canada Wide Mines Ltd. (Granduc mine)
28. Terra Mines Ltd.
29. Echo Bay Mines Ltd.

## SMELTERS

2. Noranda Mines Limited Division Mines Gaspé
9. Noranda Mines Limited
10. Falconbridge Limited
    Inco Limited
11. KCML Inc.
16. Hudson Bay Mining and Smelting Co., Limited
20. Afton Mines Ltd.

## REFINERIES

6. Noranda Mines Limited, Division CCR
10. Inco Limited
11. KCML Inc.

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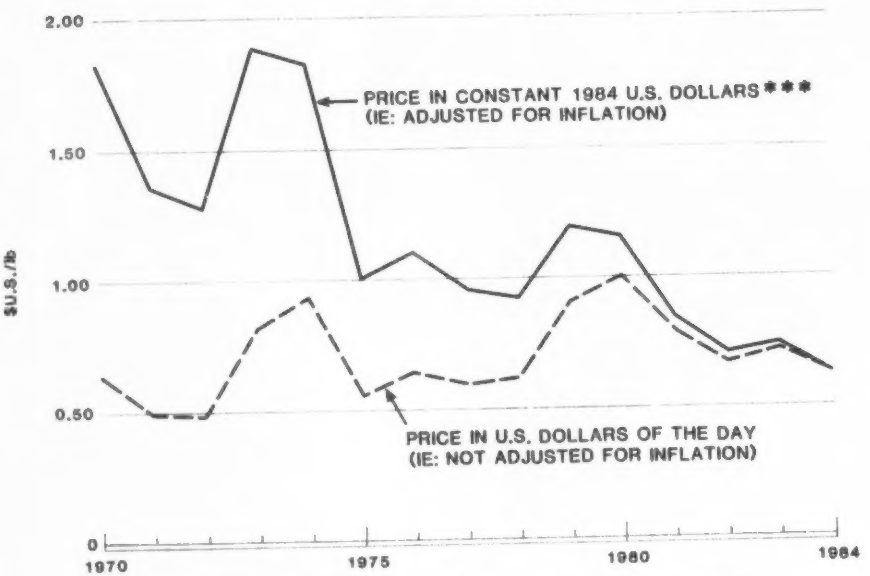
An inventory of undeveloped Canadian copper deposits is available in the publication Canadian Mineral Deposits Not Being Mined in 1983, Energy, Mines and Resources Canada, Report MRI 198, ISBN 0-660-11580-8

## AVERAGE ANNUAL PRICE* FOR COPPER**
## LONDON METAL EXCHANGE



NOTES:
- * CASH SETTLEMENT PRICE £/TONNE, CONVERTED TO $U.S./lb
- ** WIRE BAR, 1970 TO DECEMBER 1981; THEREAFTER HIGHER GRADE CATHODES
- *** USING U.S. WHOLESALE PRICE INDEX, (1984, ESTIMATED)

SOURCES : 1970-1983 COPPER PRICES, £/TONNE, WORLD BUREAU OF METAL STATISTICS; EXCHANGE RATES, BANK OF CANADA REVIEW, 1984 COPPER PRICE, METALS WEEK.

# Crude Oil and Natural Gas

### R. THOMAS

Over much of the past century, Canada's petroleum resource base has been developed in the prairie provinces' portion of the Western Sedimentary Basin with continuing production from the smaller pools of southwestern Ontario that were discovered in the 1860s. It has been estimated that the initial volume of crude oil in-place for the provinces is some $9.5 \times 10^{9}$ cubic metres ($m^3$), (60 billion barrels) of which $2.5 \times 10^{9} m^3$ (16 billion barrels) have been established. Currently, the volume of remaining established reserves is at some $0.9 \times 10^{9} m^3$ (5.6 billion barrels) indicating that over $1.65 \times 10^{9} m^3$ (10 billion barrels) have been produced to date.

In the provinces, the initial volume in-place of natural gas has been estimated to be $5\ 418 \times 10^{9} m^3$, (191 trillion $ft^3$) with some $3\ 979 \times 10^{9} m^3$ (140 TCF) in established reserves. The current estimate of remaining reserves has been placed at some $2\ 000 \times 10^{9} m^3$ (71 TCF).

The recent report published by the Geological Survey of Canada (Paper 83-31) indicates the potential remaining to be discovered for crude oil in western Canada could range between 593 million $m^3$ at average expectation and 1.210 billion $m^3$ as a speculative estimate (3.736 - 7.623 billion barrels). Comparatively, the discovery potential for natural gas may be in the range of $2\ 504 \times 10^{9} m^3$ to $4\ 930 \times 10^{9} m^3$ (89 - 175 TCF).

Another resource being developed in Canada is from Alberta's vast oil sands deposits, believed to contain approximately 159 billion $m^3$ ($1 \times 10^{12}$ barrels) of crude bitumen in-place, of which some 56 billion $m^3$ (350 billion barrels) may be recoverable. There are currently two major commercial projects, Suncor and Syncrude, that are operating in the Athabasca field from a licenced reserve base of some 3 860 million $m^3$ (25 billion barrels). The combined current output from the plants averages 20 000 $m^3$/d (126,000 b/d) from open-pit mines. Studies are being undertaken to consider the possibility of producing from sunken shafts incorporating horizontal wells. Esso Resources Canada Limited has undertaken the recovery of bitumen in the Cold Lake deposits by in-situ recovery methods. The project at Leming, has been classified as "experimental" to date with the daily bitumen production averaging 2 600 $m^3$. The expansion of the project from experimental stage to the commercial stage will be constructed in six phases. Each phase will increase the daily production by 1 500 $m^3$ and will cost approximately $150 million. The first two phases are to begin production in 1985 and the subsequent phases will be added to maintain the production over the 25-year project life. The capital cost of the entire project is expected to be in the order of $1.5 billion. Other major heavy ore and bitumen projects are underway at Lindbergh (Dome, Sulpetro, CNG), Peace River (Shell), Wolf Lake (BP Canada, Petro-Canada) and Fort Kent (Suncor, Canadian Worldwide Energy).

In addition to the oil and gas resources previously mentioned, there remains the technique of further extracting crude oil from older existing pools through "enhanced oil recovery", which recover crude that has been left in the ground after primary and secondary (waterflood) production. Techniques used include: chemical, steam stimulation, carbon dioxide, and wet/dry thermal flooding. The Geological Survey of Canada estimates the enhanced oil recovery's potential may range from 160 to 950 million $m^3$ (1 to 6 billion barrels).

During 1984, the expected production of petroleum from Canada's provinces may average 280 700 $m^3$/d (1.77 million barrels) which includes conventional crude, synthetic crude, pentanes plus/condensate and natural gas liquids. The bulk of this output comes from western Canada with Alberta being the largest producer of oil and natural gas. It is anticipated that Alberta will account for some 243 160 $m^3$/d of liquid petroleum or about 87 per cent.

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The production of natural gas is expected to average 180 million $m^3$/d (6.4 billion $ft^3$/d) in 1984 of which some 53 million $m^3$ was exported to the United States, and the balance was consumed domestically. Again, Alberta accounted for 89 per cent of total Canada output. Ontario is the greatest consuming province of gas where much of the throughput is allocated for the industrial sector. From total domestic sales, some 54 per cent is absorbed by major industries, 26 per cent is sold to residences and the remaining 21 per cent is consumed by the commerical sector.

The last record year for drilling in the provinces was in 1980, in which some 9,200 wells were completed while a low of 5,800 completions occurred in 1982. In 1984, it is anticipated that drilling will nearly equal the amount recorded in 1980. Statistics compiled to the end of the third quarter show more than 4,200 oil wells, almost 1,300 gas wells and 1,300 dry holes for a total exceeding 6,800 completions. The current trend in drilling has shifted toward oil where markets are more firm because of domestic and export demand. Well completions for the year could total 9,100 wells and aggregate metrage attained may be 10.2 million m.

Over the past year, additional discoveries of oil in established regions were made in western Canada in areas such as: Pembina, Redwater, Swan Hills, Mitsue, and Willesden Green. Significant discoveries have been made in new oil plays as shown on the accompaning map of western Canada. In Ontario, oil and natural gas continue to be from old pools. Most of the old oil wells are on pumping and many wells are producing about 1 $m^3$/d. Much of the natural gas in the province is from Lake Erie, where operations are conducted on barges or jack-up rigs. There was very little oil and gas activity on land in Quebec and the Maritimes.

Canada's refining industry has seen many changes during the recent past. Throughout the country, the demand for oil has been decreasing due to slack markets, conservation and oil-substitution programs by natural gas. Several refineries closed in eastern Canada and others have rationalized their operations to fully utilise capacity. During the past two years, natural gas from western Canada has been increasingly shipped into Ontario and Quebec through the TransCanada PipeLines and the TransQuebec and Maritimes Line. The TQM pipeline transports some 13.4 million $m^3$/d of gas into Quebec.

In June, 1984, an agreement was reached among federal-provincial governments (Alberta and Saskatchewan) and Husky Oil Ltd. in which a heavy oil upgrader would be constructed in order to convert heavy oil and crude bitumen into a synthetic oil suitable for refining in Canada. This plant, costing around $2.0 billion, will produce 6 667 $m^3$/d (42,000 b/d) of synthetic crude oil upon its completion, expected in 1989. Located in Lloydminster, the feedstock would be drawn from Cold Lake (Alberta) and the Lloydminster area, bordering Alberta and Saskatchewan.

The pricing of crude oil in Canada is calculated on the basis of its quality (density and sulphur content) and year produced. The two types of crude are: New Oil Reference Price (NORP - post 1974) and Conventional Oil Oil Price (COOP - pre-1974), with the reference price for each based on a quality of 38°API and a sulphur content of 0.7 per cent. The wellhead price for a NORP crude in this category would be \$252.35/$m^3$ (\$Cdn 40.00/bbl) and a corresponding COOP price would be \$185.85/$m^3$ (\$Cdn 29.50/bbl).

The price of domestic natural gas is based on the gigajoule, where 1GJ = 0.95 million BTU. The current field gate price of gas is $Cdn 2.099/GJ and its export price is $Cdn 5.407/GJ;, or respectively $1.99/MCF and $4.14/MCF. In a late year amendment to export pricing, an agreement was reached between the federal government and six companies that these exporters could negotiate a price with American buyers that would make Canadian gas more competitive in the market place. This change in pricing policy was necessary because the volumes exported to the United States were considerably less than the amount under contract. The average negotiated prices will be in the range of $US 3.25 - $3.35/million BTU, comparable to the Canadian eastern market import price of $US 3.15/million BTU. This newly negotiated price is anticipated to account for some $US 2.4 billion in revenue out of a total expected $US 3,100 million from the sales of natural gas to the United States in the coming year.

As 1984 has seen a marked improvement in overall industry activity levels, it is expected to continue through 1985. The federal and provincial governments, through changes in policies and prices, have encouraged the petroleum sector to promote new and additional projects necessary to ensure Canada's supply of oil and natural gas.

Additional oil sands projects, enhanced recovery schemes, heavy oil upgraders, and further development of natural gas are expected as the country's resource potential is more fully realized.

## SUMMARY

Heavy oils and bitumen are composed of high carbon to hydrogen ratio, hydrocarbons having a small distillable fraction, high sulphur and traces of heavy metals. They are defined: a) by viscosity being respectively below and above $10^5$ mPa.s, and b) by having a density of 934-1 000 kg/$m^3$ (20-10° API) and above 1 000 kg/$m^3$ (10°API).

Deposits of oil sands (bitumen) are found in Peace River, Wabasca, Athabasca and Cold Lake, changing to heavy oils in Lloydminster and south along the Alberta-Saskatchewan border through Wainwright, Colville, Suffield and Taber.

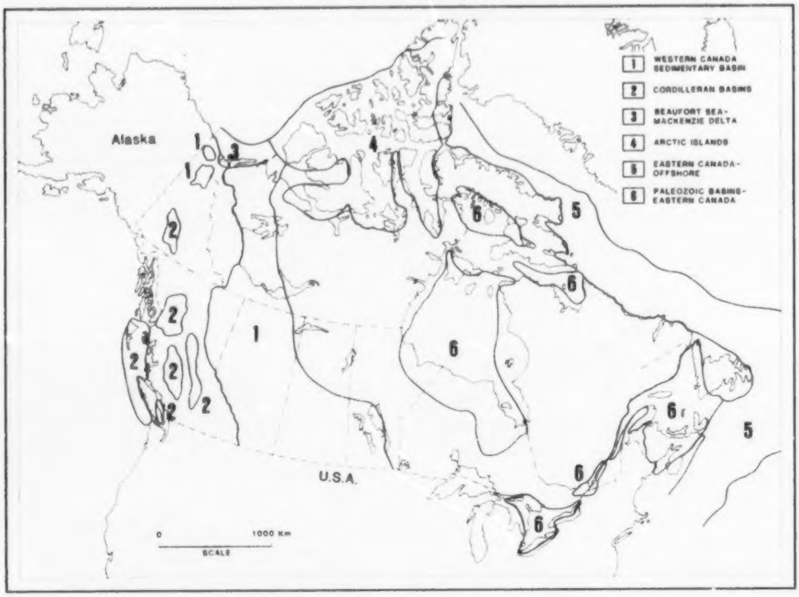
Total bitumen in-place in the oil sands and underlying "carbonate triangle" are about one trillion barrels and over 10 billion barrels for the heavy oils. Current production of bitumen is about 33,500 b/d and could rise to 140,000 b/d from existing projects by the year 1990. Undiluted heavy oil production from Alberta and Saskatchewan is about 176,000 b/d of which over 25 per cent is from Lloydminster.

There are 86 approved heavy oil and bitmen extraction operations, including Syncrude and Suncor, of which 48 are in oil sands experimental projects, 22 heavy oil projects in Alberta and 14 projects in Saskatchewan. Technologies used are surface mining and cyclic steam injection (huff and puff) for bitumen and steam and fireflooding for heavy oils. The use of mine shafts for bitumen recovery instead of surface mining is being tested to avoid overburden removal and sand handling.

The greatest potential for large and commercially viable production is at Cold Lake as indicated by the Esso Leming Lake, BP Wolf Lake, Amoco Elk Point and Suncor Ft. Kent projects. New surface mining projects are constrained by the large capital investment and operational costs, oil price risks, and environmental problems. A combination of mine shaft and steam thermal recovery may be the way to reduce costs.

Fifty billion barrels of heavy oils and bitumen are recoverable by existing technology. This provides a major opportunity for exports. Large amounts of capital are required and foreign investment should be encouraged allowing for exports of both domestic and crude, upgraded and synthetic oils surplus to our needs. Tax and royalty incentives should be continued to maintain competitiveness and to encourage new technologies.

## CANADA'S PETROLEUM REGIONS


1 WESTERN CANADA SEDIMENTARY BASIN
2 CORDILLERAN BASINS
3 BEAUFORT SEA-MACKENZIE DELTA
4 ARCTIC ISLANDS
5 EASTERN CANADA-OFFSHORE
6 PALEOZOIC BASINS-EASTERN CANADA
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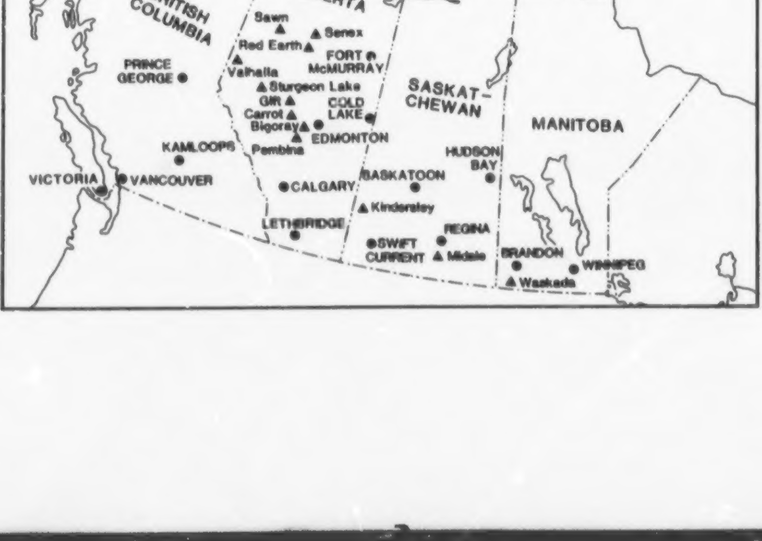
## SIGNIFICANT NEW OIL PLAYS


BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
Thetlaandoa
Desan
FORT NELSON
Shekilie
Sawn
Senex
Red Earth
FORT McMURRAY
Valhalla
PRINCE GEORGE
Sturgeon Lake
Gift
Carrot
COLD LAKE
Bigoray
EDMONTON
Pembina
KAMLOOPS
VICTORIA
VANCOUVER
CALGARY
SASKATOON
HUDSON BAY
Kindersley
LETHBRIDGE
REGINA
SWIFT CURRENT
Midale
BRANDON
WINNIPEG
Waskada

# Ferrous Scrap

R. McINNIS

## INTRODUCTION

1983 marked the beginning of a slight improvement in consumption of purchased scrap with volumes of 3.09 million t compared to 2.5 million t in 1982. The improvement continued in 1984 with a total estimated to be 3.8 million t.

Canadian scrap consumption including own generated scrap improved from 6.8 million t in 1982 to 7.5 million t in 1983 with further gains to a level estimated at 8.9 million t for 1984.

Demand for increased quality of product, especially in terms of the chemical analysis by scrap users, will continue as the world steel industry continues to increase the quality and strength of the steel they produce.

## CANADIAN INDUSTRY STRUCTURE

The Canadian ferrous scrap industry totals approximately 600 firms. The companies collect, store and process the ferrous scrap purchased by the user industries, generally steel companies. Most of these firms are small and are involved only in the collection of scrap; dealers who are involved in the sorting and storage of scrap are fewer in number, while the capital intensive processors are the smallest in number. A processor requires such equipment as mechanical shredders, shears, presses and bundlers. They are the most important segment of the scrap industry as they produce the products needed by the user industries.

Scrap is such an important input that Canadian steel producers often have equity ownership in scrap processing companies so as to minimize supply problems.

In terms of capital equipment autobody shredders represent a significant capital investment. However the 15 machines presently installed has the capacity to process about 1.3 million cars per year.

## CANADIAN DEVELOPMENTS

The Canadian ferrous scrap industry was severely depressed in 1982 and early-1983. However, during the second half of 1983 demand increased and prices improved rapidly.

In an integrated steel mill the ratio of purchased to own generated scrap varies from year to year. In 1981 this ratio was 1.0 it decreased to .89 in 1982 and fell to .89 in 1983. This ratio is not simply a function of price although price is important. Prices in 1982 were very low and relatively less purchased scrap was consumed. Steelmakers tend to maximize the use of scrap in normal markets because scrap is virtually always cheaper than the cost of producing molten pig iron and the more scrap used the lower the cost of producing steel. When demand for steel is very high scrap use is maximized to increase the amount of steel produced in the steel mill. The alternative can also be true with mills not maximizing their use of scrap in order to operate their blast furnace at a reasonable rate or to utilize contracted supplies of iron ore or coal. This latter situation may explain the low scrap to steel ratio of 1982, that is quantity of scrap consumed per tonne of steel produced.

In the case of the electric furnace steel industry the price demand relationship is much more direct as ferrous scap is virtually the entire source of raw materials. In periods of low demand and low scrap prices, electric furnace mills can produce steel for considerably less than integrated mills allowing them to capture market share and the increasing spread between the price of scrap and the price of steel helps them to remain profitable in periods of low demand.

Increasing use of continuous casting and improved basic oxygen furnace (BOF), such as the LBE equipment recently installed and in planning steel mills will reduce the levels of own generated scrap and increase the

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relative demand for purchased scrap, as will the entrance of QIT Fer et Titane into the production of steel. QIT produces pig iron as a coproduct with titanium oxide in its electric furnace ilmenite smelting facilities at Sorel, Quebec. The company's decision to further process this high-purity molten iron to billets was based on the following factors; a severe downturn in the company's historic market for pig iron in Europe and the United States, the qualification of the project for government grants, and a risk sharing contract with Hydro Quebec.

This new steelmaking facility will impact on the ferrous scrap industry as a potential customer because with their capacity to produce 440 000 t of billet they could use up to 132 000 t of scrap. Further, the reduction in pig iron production could also increase demand for scrap.

Canada is more than self-sufficient in scrap but there are regional differences in supply and consumption that influence the bilateral trade in scrap that exists between Canada and the United States. Scrap surplus to eastern Canadian needs is often exported to markets in the northeastern United States while the western Canadian market which is generally deficient in local scrap generally imports it from the American northwest and central regions where there is little steelmaking capacity.

The recycling industries of both Canada and the United States share, what to a great extent is, a single market as there are few restraints to the movement of scrap across the border and the prices set in the United States have a major impact on the Canadian price of the same product. Most Canadian exports of scrap go to the United States, over 90 per cent in the last three years while virtually all of Canadian imports originate in the United States.

As the recycling industry in Canada has grown and become more mechanized and efficient an increasing surplus has been available for export. The international market for scrap is very competitive and a good market this year may disappear next year. Countries which have a history of buying significant volumes of scrap include South Korea, Spain, Italy and Japan.

## USES

Most ferrous scrap is used in the production of steel in both electric furnace and integrated mills. The foundry industry is the second largest market for scrap while production of iron powder is a minor market.

Scrap is classified by grade and specification, and also by source or type. There are three major types of scrap. Home scrap, which is produced in the manufacture of steel mill products; Prompt industrial scrap, which is generated by the secondary manufacturing industry; and Obsolete scrap, which comes from worn out discarded machinery, equipment and structures.

Prompt and obsolete scrap is generally processed by the recycling industry and is available in a number of grades and to various specifications that concern chemical analysis and the shapes and section of the product. Number 1 heavy melting steel, and number 1 shredded scrap are examples of some of the products available.

The electric furnace steel industry is the largest consumer of scrap in Canada operating on virtually 100 per cent scrap feed. The scrap to finished steel ratio for the industry averages 1.1 to 1.2 depending on the grade of scrap charged that is it takes 1100 to 1200 kg of scrap to produce 1000 kg of steel. The grade also influences the time required to melt each heat and the cost of energy per tonne and thus the productivity of the furnace. The quality of the steel produced is influenced by the amount of tramp elements present in the scrap.

In the integrated steel industry, scrap is charged to both the open-hearth and BOF at about 50 per cent and 30 per cent respectively. Because scrap is a much cheaper source of iron than the blast furnace, integrated steel mills tend to maximize the scrap charged to their steel furnace.

There is considerable research and development work presently under way and completed, the purpose of which is to increase the percentage of scrap that can be used in the integrated steel industry.

## OUTLOOK

The largest consumer of iron and steel scrap is the steel industry; thus consumption of scrap is a direct function of the level of steel production. In the case of the electric furnace industry scrap consumption is a direct function of steel production. However, the integrated steel industry has considerable flexibility in the percentage of scrap they feed to their steel furnaces. In a BOF a small amount of scrap is necessary to absorb the energy released when the carbon in the molten iron is removed by oxidisation, this same energy can be used to melt up to about 30 per cent scrap. The scrap to iron ratio used is a function of such variables as the price of scrap, the operating rate of the steel mill and the existence of contracts for imput materials such as coal and iron ore. In a period of high demand when a mill is operating near capacity, scrap use will be maximized to increase the amount of steel produced even if the price is high. The alternate situation also applies. When demand is low the minimum output from a blast furnace is such that scrap use even if very low priced, is reduced to avoid over production. In the longer-term, both integrated and electric furnace mills are experiencing rapid technological change which will have an impact on the scrap market. In periods of normal market demand the industry tends to maximize its use of scrap because the cost of a tonne of scrap is generally much less than the cost of producing a tonne of molten pig iron. Recent research and development efforts have been focused on increasing the amount of scrap that can be used in the oxygen steel converter or BOF. Developments include systems where fuel and oxygen are blown into the converter to preneat the scrap charge and Lance Bubbling Equilibrium (LBE) equipment which blows inert gases through the bottom of a BOF type vessel. The resultant mixing improves the yield of the amount of scrap that can be charged and the quality of the steel produced. LBE equipment is being installed in a number of Canadian BOF's. The market for scrap and the amount of scrap purchased by integrated mills also varies with the amount of home scrap produced in the steel plant, and again a new process in continuous casting is effecting the ratio of home to purchased scrap. Yields from molten crude to finished steel can increase by almost 20 per cent when continuous casting is used instead of the ingot roughing mill route. At least 3 new C.C.machines will be installed in Canadian mills in the next few years.

In 1985 scrap usage is expected to increase by approximately 3 per cent per year. In the medium-term to 1990 usage should increase 4 to 5 per cent per year. In the longer-term to 1995 growth should average approximately 2 per cent per year.

Demand for higher quality scrap, especially in terms of low levels of tramp elements will likely require the installation of more equipment such as x-ray spectrometers to analyse scrap, mechanical separators, high pressure bailers and briquetters that produce a higher density product, and improved shredders that increase the separation of nonferrous and nonmetallic components, of the materials in the feed, i.e. automotive hulk.

## PRICES

The composite prices in U.S. dollar per long ton delivered, for No. 1 heavy melting steel scrap, as quoted by the American Metal Market increased from $59.2 in January 1983 to $86.99 in December. Prices continued to increase in 1984 with the highest price of $96.25 occuring in February when it fell to a low of $79.17 at year-end.

**TABLE 1. CANADA, EXPORTS OF STEEL SCRAP, BY PROVINCE OF LADING, 1981-83**

| | | 1981 | | 1982 | | 1983P | |
|---|---|---|---|---|---|---|---|
| | | World | U.S. | World | U.S. | World | U.S. |
| Newfoundland | tonnes | - | - | - | - | 1 910 | - |
| | $000 | - | - | - | - | 170 | - |
| Nova Scotia | tonnes | 29 | 29 | - | - | 38 | 38 |
| | $000 | 2 | 2 | - | - | 60 | 60 |
| New Brunswick | tonnes | 340 | 200 | 485 | 425 | 475 | 475 |
| | $000 | 71 | 14 | 55 | 27 | 37 | 37 |
| Quebec | tonnes | 114 663 | 12 896 | 156 651 | 21 326 | 105 496 | 3 415 |
| | $000 | 14,672 | 2,005 | 15,659 | 2,288 | 10,437 | 416 |
| Ontario | tonnes | 235 487 | 233 326 | 220 134 | 162 618 | 549 008 | 438 215 |
| | $000 | 28,461 | 28,134 | 20,811 | 15,880 | 42,398 | 31,095 |
| Manitoba | tonnes | 1 472 | 1 472 | 1 410 | 1 410 | 836 | 836 |
| | $000 | 281 | 281 | 194 | 194 | 87 | 87 |
| Saskatchewan | tonnes | 2 195 | 2 195 | 3 | 3 | 161 | 161 |
| | $000 | 381 | 381 | 1 | 1 | 30 | 30 |
| Alberta | tonnes | 1 288 | 1 266 | 1 377 | 1 377 | 607 | 587 |
| | $000 | 197 | 192 | 125 | 125 | 106 | 100 |
| British Columbia | tonnes | 90 769 | 87 068 | 85 687 | 84 263 | 130 178 | 128 471 |
| | $000 | 9,889 | 9,272 | 7,568 | 7,136 | 11,529 | 11,209 |
| Yukon | tonnes | 72 | 72 | - | - | - | - |
| | $000 | 4 | 4 | - | - | - | - |
| Canada total | tonnes | 446 315 | 338 524 | 465 747 | 271 422 | 788 709 | 572 198 |
| | $000 | 53,958 | 40,285 | 44,413 | 25,651 | 64,854 | 43,034 |

Source: Statistics Canada.
P Preliminary; - Nil.

**PRICE INDEX (1971 = 100)**

| Product | 1981 | 1982 | 1983 | 1984 |
|---|---|---|---|---|
| Ferrous Scrap (Average) | 254.3 | 216.5 | 222.6 | 277.4 |
| No. 1 Heavy Melting | 243.3 | 207.3 | 208.6 | 268.8 |
| Nos. 1 & 2 Bunders | 245.1 | 216.5 | 222.1 | 240.2 |
| Steel Foundry Scrap | 294.5 | 246.8 | 254.8 | 319.9 |

Source: Statistics Canada.

## TABLE 2. CANADA, IMFORTS OF STEEL SCRAP, BY PROVINCE OF ENTRY, 1981-83

| | | 1981 | | 1982 | | 1983P | |
|---|---|---|---|---|---|---|---|
| | | World | U.S. | World | U.S. | World | U.S. |
| Nova Scotia | tonnes | - | - | --- | --- | 86 | 86 |
| | $000 | - | - | --- | --- | 6 | 6 |
| New Brunswick | tonnes | 1 131 | 1 131 | 62 | --- | 19 | 19 |
| | $000 | 89 | 89 | 16 | --- | 2 | 2 |
| Quebec | tonnes | 60 701 | 60 659 | 28 605 | 26 785 | 26 998 | 26 952 |
| | $000 | 5,486 | 5,405 | 2,812 | 2,741 | 3,479 | 3,446 |
| Ontario | tonnes | 311 917 | 311 840 | 194 335 | 194 291 | 262 360 | 262 281 |
| | $000 | 30,648 | 30,592 | 15,376 | 15,350 | 20,783 | 20,726 |
| Manitoba | tonnes | 55 781 | 55 781 | 8 233 | 8 233 | 25 815 | 25 815 |
| | $000 | 4,390 | 4,390 | 514 | 514 | 1,852 | 1,852 |
| Saskatchewan | tonnes | 127 733 | 127 733 | 68 005 | 68 005 | 135 008 | 135 008 |
| | $000 | 13,419 | 13,419 | 5,337 | 5,337 | 10,511 | 10,511 |
| Alberta | tonnes | 24 600 | 24 600 | 3 291 | 3 291 | 14 798 | 14 798 |
| | $000 | 2,423 | 2,423 | 315 | 315 | 1,108 | 1,108 |
| British Columbia | tonnes | 2 005 | 1 956 | 926 | 926 | 1 489 | 1 483 |
| | $000 | 270 | 265 | 109 | 109 | 537 | 536 |
| Canada total | tonnes | 583 869 | 583 700 | 303 458 | 301 533 | 466 573 | 466 442 |
| | $000 | 56,724 | 56,583 | 24,479 | 24,366 | 38,278 | 38,187 |

Source: Statistics Canada.
P Preliminary; - Nil; --- Amount too small to be expressed.

TABLE 3. CANADA, EXPORTS OF STAINLESS STEEL SCRAP, BY PROVINCE OF LADING, 1981-83

| | | 1981 | | 1982 | | 1983P | |
|---|---|---|---|---|---|---|---|
| | | World | U.S. | World | U.S. | World | U.S. |
| Newfoundland | tonnes | 14 | 14 | - | - | - | - |
| | $000 | 3 | 3 | - | - | - | - |
| Nova Scotia | tonnes | 140 | 122 | 133 | 13 | 46 | 5 |
| | $000 | 116 | 102 | 84 | 11 | 42 | 12 |
| New Brunswick | tonnes | 350 | 281 | 273 | 10 | 83 | - |
| | $000 | 263 | 221 | 197 | 6 | 68 | - |
| Quebec | tonnes | 2 136 | 1 519 | 4 403 | 1 496 | 2 108 | 1 172 |
| | $000 | 1,942 | 1,398 | 3,065 | 894 | 1,696 | 876 |
| Ontario | tonnes | 12 011 | 11 377 | 15 982 | 9 890 | 14 905 | 11 328 |
| | $000 | 6,953 | 6,277 | 9,138 | 4,366 | 9,310 | 6,718 |
| Manitoba | tonnes | 163 | 163 | 283 | 283 | 177 | 177 |
| | $000 | 75 | 75 | 144 | 144 | 121 | 121 |
| Saskatchewan | tonnes | - | - | - | - | - | - |
| | $000 | - | - | - | - | - | - |
| Alberta | tonnes | 39 | 39 | 223 | 223 | 137 | 137 |
| | $000 | 26 | 26 | 168 | 168 | 74 | 74 |
| British Columbia | tonnes | 1 589 | 868 | 2 608 | 1 530 | 1 460 | 543 |
| | $000 | 1,031 | 522 | 1,032 | 339 | 944 | 196 |
| Canada total | tonnes | 16 442 | 14 383 | 23 905 | 13 445 | 18 916 | 13 362 |
| | $000 | 10,409 | 8,624 | 13,828 | 5,928 | 12,255 | 7,997 |

Source: Statistics Canada.
P Preliminary; - Nil.

**TABLE 4. AUTOMOBILE SHREDDERS IN CANADA**

| Company | Location | Capacity (tonnes/month) |
|---|---|---|
| Intermetco | Hamilton, Ontario | 8 000 |
| United Steel and Metal | Hamilton, Ontario | 5 000 |
| Bakermet | Ottawa, Ontario | 8 000 |
| Industrial Metals Co. of Canada | Toronto, Ontario | 10 000 |
| Zalev Brothers Limited | Windsor, Ontario | 6 000 |
| Sidbec-Feruni Inc. | Contrecoeur, Quebec | 8 300 |
| Fers et Metaux Recyclés Ltée | Longueuil, Quebec<br>Laprairie, Quebec | 4 000<br>4 000 |
| Associated Steel Industries Ltd. | Montreal, Quebec | 6 000 |
| Native Auto Shredders | Regina, Saskatchewan | 6 000 |
| Cyclomet | Moncton, New Brunswick | 4 000 |
| Navajo Metals Ltd. | Calgary, Alberta | 3 000 |
| Stelco Inc. | Edmonton, Alberta | 8 000 |
| Richmond Steel Recycling Ltd. | Richmond, British Columbia | 5 800 |
| General Scrap & Car Shredder Ltd. | Winnipeg, Manitoba | 3 000 |
| Total | | 85 100 |

**TABLE 5. CANADIAN CONSUMPTION OF IRON AND STEEL SCRAP**

| | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983P | 1984P (Jan.-Sept.) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | (000 tonnes) | | | | |
| Used in steel furnaces | 5 997 | 5 658 | 5 708 | 7 076 | 7 250 | 7 501 | 6 845 | 5 492[2] | 6 000 | 5 020 |
| Used in iron foundries | 544 | 550 | 524 | 518 | 604 | 470 | 500 | 448 | 500 | 360 |
| Other[1] | 846 | 824 | 938 | 865 | 868 | 770 | 926 | 837 | 1 000 | 620 |
| Total | 7 387 | 7 032 | 7 170 | 8 459 | 8 722 | 8 741 | 8 271 | 6 777 | 7 500 | 6 000 |

Sources: 1982 Annual Census of Manufactures. 1983 and 1984 Catalogue 41-001 Primary Iron and Steel.

[1] Includes mainly steel pipe mills, motor vehicle parts industries, and railway rolling stock industries. [2] The number from Catalogue 41-001 was 4,619 or within 2.3 per cent.

P Preliminary.

**TABLE 5. CANADIAN CONSUMPTION OF IRON AND STEEL SCRAP**

| | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983P | 1984P |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | (000 tonnes) | | | | (Jan.-Sept.) |
| Used in steel furnaces | 5 997 | 5 658 | 5 708 | 7 076 | 7 250 | 7 501 | 6 845 | 5 492[2] | 6 000 | 5 020 |
| Used in iron foundries | 544 | 550 | 524 | 518 | 604 | 470 | 500 | 448 | 500 | 360 |
| Other[1] | 846 | 824 | 938 | 865 | 868 | 770 | 926 | 837 | 1 000 | 620 |
| Total | 7 387 | 7 032 | 7 170 | 8 459 | 8 722 | 8 741 | 8 271 | 6 777 | 7 500 | 6 000 |

Sources: 1982 Annual Census of Manufactures. 1983 and 1984 Catalogue 41-001 Primary Iron and Steel.

[1] Includes mainly steel pipe mills, motor vehicle parts industries, and railway rolling stock industries. [2] The number from Catalogue 41-001 was 4,619 or within 2.3 per cent.

P Preliminary.

# Gold

D. LAW-WEST

After eighteen months of downward pressure, the price of gold at the end of 1984 had fallen to a two year low of slightly above $US 300 per oz. This caused considerable concern in the Canadian gold mining industry as some higher cost producers became unprofitable and other producers experienced reduced cash flows. Despite weakening prices over this period, several new mines came on stream and only a few of the very high cost producers were forced to shut down.

The price of gold on the London market was in the $US 370 to $US 380 range in early 1984, fell to about $US 340, where it remained until December when the price averaged $US 320.

Despite the lower prices, gold production appears to be increasing in several countries including Canada, Australia, Brazil and the United States.

The future price of gold will depend on the strength of the major OECD economies, interest rates, inflation rates, gold sales from Comecon countries, and the ability of OPEC countries to maintain high oil prices. The short-term outlook for gold prices indicates continued weakness.

## CANADIAN DEVELOPMENTS

Canada's primary production of gold in 1984 was estimated at 81 300 kg which was 9.5 per cent higher than the 73 513 kg produced during 1983. The largest increases in production occurred in the Northwest Territories, Quebec and Ontario.

In Atlantic Canada, an increase in gold production of about 150 kg in 1984, was primarily attributable to the successful efforts of New Brunswick Mining and Smelting Corporation to increase gold recovery from reprocessed slimes. In addition two small gold producing operations opened up, Anaconda Canada Exploration Ltd. and the Heath Steele Mines Ltd. in New Brunswick.

Selco a division of BP Canada announced a significant gold discovery near Port aux Basques, Newfoundland. The company expects to complete drilling and be ready to conduct a feasibility study, by mid-1985.

Gold exploration in Nova Scotia picked up significantly during 1984. Several companies secured financing for more detailed work and feasibility studies which, if positive, could re-establish the province as a gold producer.

In Quebec, which retained its position as the country's largest gold producer, production increased by some 7 per cent to 29 282 kg. There were several significant new mines which came on-stream in 1984.

Corporation Falconbridge Copper opened its Lac Shortt gold mine in northern Quebec. The mine is expected to produce 1 555 kg of gold per year from its 750 tpd mill. There is a possibility that the mill rate could be doubled in the future. The mine, with reserves estimated at 2.4 million t grading 4.8 g/t has an expected life of 8 to 9 years.

Agnico Eagle Mines continued with the development and mining at its Tebel Mine which adjoins the Eagle mine near Joutel, Quebec. The company completed the sinking of a 1 200 m production shaft and is mining on the 775 m level. Ore from the Tebel mine accounts for 50 per cent of Agnico's mill feed.

Kiena Gold Mines opened its new 1 250 tpd mill in September. Gold production from the mill is expected to be 2 080 kg per year. Prior to the completion of the mill, Kiena had been trucking its ore to the Lamaque mill under the terms of a contract that runs until January 1985. Operating costs for Kiena are expected to drop from about $US 250/oz to about $US 200/oz.

Aiguebelle Resources opened a new mill facility at the D'est-Or mine near Rouyn.

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The 1 000 tpd mill will eliminate the company's need to truck its ore 100 miles to Louvem's Manitou mill. The company expects to produce some 1 244 kg of gold in 1984 up from the 622 kg the previous year.

Société Miniere Louvem reopened the Chimo mine, after deepening the shaft from 175 m to 335 m and opening up four new mining levels. In addition the company completely rebuilt the 900 tpd Manitou mill. Initial output is expected to be 500 kg per year from a mill rate of 300 tpd. Eventual output is expected to reach 1 860 kg per year. Proven ore reserves at the mine are some 950 000 t grading 7.78 g/t. However, mining and milling operations were expected to be suspended early in 1985, to enable development of the new ore zone. When the mine reopens production will be from both existing stopes and the new zone at an initial rate of 400 tpd. This will increase to 700 tpd by the end of 1985.

Northgate Exploration increased gold production at its Copper Rand and Portage mine near Chibougamau from 1 910 kg in 1983 to some 2 050 kg in 1984. This increase is largely the result of a $12.5 million development and expansion program.

In Ontario, Dome Mines continued with an expansion program which included completely rebuilding the mill and sinking the new No. 8 shaft. Production is expected to increase by about 50 per cent by early-1985. The mill capacity was increased to 2 500 tpd, since the new shaft will allow more direct ore haulage.

Pamour Porcupine Mines announced the closure of three of its six mining operations, during the fourth quarter of 1984. The suspension will entail a reduction in workforce of 480 employees, however, the mines will be maintained on standby to permit reopening, should gold prices recover.

At the Detour Lake gold mine, a joint venture between Campbell Red Lake Gold Mines and Amoco Canada Petroleum, construction of 2,200 ft shaft was scheduled to commence by the end of 1984. The 2 750 tpd mill has been operating on ore from the open-pit mine. Production for the first half of 1984 was 920 kg of gold. Development plans call for eventual mill expansion to 4 400 tpd. This would make Detour Lake mine one of the country's largest producers.

Campbell Resources is in the process of expanding output at its Renabie mine near Missinabi, Ontario. The company expects to spend some $17 million to expand production to 1 000 tpd and to recover some 1 860 kg of gold per year by 1986. Underground drilling has outlined large reserves grading about 8.1 g/t at depth.

Westfield Mines began operation of its 200 tpd mill at its gold mine in Scadding Township near Sudbury. The company expects to produce some 1 090 kg of gold during the four year life of the operations.

The McBean mine near Kirkland Lake poured its first gold bar in mid-1984. The operation, a joint venture between Inco Limited (65 per cent) and Queenston Gold Mines (35 per cent), represents the culmination of over 50 years of exploration and development in the area. Operating at 500 tpd, the operation is expected to produce some 620 kg of gold per year. The open-pit is expected to reach its maximum depth of 80 m within 3 to 4 years. The ore is processed in the refurbished Upper Canada mill which had operated between 1939-72.

The Hemlo area of northern Ontario remained the focus for development and exploration in the province. In a joint venture, Teck Corp. (55 per cent) and International Corona Resources (45 per cent), plan to spend some $157 million to construct a 1 000 tpd mine/mill complex on their Hemlo property. Ore production is expected to begin early in 1985 and the mill is expected to begin operating in April 1985. Proven ore reserves are estimated at 8.4 million t grading 11.19 g/t of gold.

Noranda Corp. is also expected to begin production from its Hemlo property early in 1985. The company will spend about $250 million on a 915 m production shaft and a mill with initial capacity of 1 000 tpd, but which could be expanded in stages to 4 000 tpd. The proven reserves are estimated at 24 million t grading 8.71 g/t. Noranda with 50 per cent interest has optioned this property from Golden Sceptre Resources Ltd. and Goliath Gold Mines Ltd. which each hold 25 per cent interest.

Lac Minerals Ltd., has reached the 107 m level via a 1 500 m decline and plans to start sinking a 7 m diameter shaft by the year-end on its Hemlo deposit. Initial plans call for a 3 000 tpd mill with options for expansion to 6 000 tpd. Lac Minerals has proven reserves of about 42 million t grading 7.15 g/t.

The Hemlo find has stimulated exploration activities in several previously explored areas. At Cameron Lake potentially mineable reserves have been blocked out by Nuinsco Resources Ltd. - Lockwood Petroleum Inc. joint venture. Lytton Minerals has been actively drilling just west of Hemlo and has uncovered what appears to be a significant gold discovery.

The Matheson area south of Lake Abitibi has also become a recent focus of exploration where, at the end of 1984, some 16 drills were active. The most advanced project was that of Barrick Resources with six drills active.

In Saskatchewan, Flin Flon Mines officially opened its Rio mine and milling complex. Initial feed for the 125 tpd mill will come from the Rio deposit which has reserves of 163 000 t grading 9.02 g/t. Two other gold deposits are part of the producing property; the Maloney deposit with reserves of 15 000 t at 14.0 g/t and the Newcor deposit of 42 600 t grading 9.60 g gold, 27.4 g silver, 4.10 per cent zinc, and 0.4 per cent copper per t. The mill which could be expanded to 250 tpd, uses the "carbon in leach process" to recover precious metals.

Erickson Gold Mines Ltd. is in a development stage at its gold mining operations near Cassiar, British Columbia. The company is developing additional underground ore to supply the existing mill capacity of 300 tpd.

Most gold production in British Columbia is as a byproduct of base-metal operations. Some producing companies include Noranda, Placer Development, Utah Mines Ltd. and Falconbridge.

The Cariboo-Quesnel gold belt has become an area of active exploration. Dome Mines has uncovered a 1 million t at 6.2 g/t deposit. Mt. Calvery Resources has acquired several gold properties with initial showings of up to 28 g/t gold, although reserves have not yet been established.

Queenstake Resources, a major placer gold operator in the Yukon Territory, produced some 6,300 oz of gold in 1984. The company expects to increase production in 1985.

The Mount Skukum gold deposit owned by AGIP Canada may be the next gold mine in the Yukon. To date some 165 000 t of reserves grading 22.7 g/t of gold and 19.6 g/t of silver have been outlined.

Echo Bay Mines carried out an expansion program aimed at increasing gold production by 20 per cent to about 5 560 kg per year at its Lupin Mine in the Northwest Territories. In addition to increasing output the company has reduced operating costs to about $US 207 per oz. The Lupin mine was the second largest gold producer in Canada at the end of 1984.

Giant Yellowknife Mines brought its small but high-grade Salmita gold mine into production, in mid-1983. Reserves are 190 000 t grading 21.12 g/t. However, production was less than expected due to the hardness of the ore, which created milling problems and reduced recovery.

## WORLD DEVELOPMENTS

In South Africa, mine production for 1984 was estimated 680 t from 677.3 t in 1983. This slight increase was accounted for by an increase in the tonnes of ore milled as opposed to mining of higher grade ore.

The South African government decided not to discontinue its State Assistance program for marginal South African gold producers. The decision was based on the continued weakness of the gold price. However, the gold mining industry continued to be adversely affected by the 20 per cent mining surcharge tax, which the government had raised from 5 per cent in 1983.

Canadian mining companies have made significant inroads into the gold mining industry in the western United States. Lacana Mining Corporation, through its 75 per cent owned Lacana Gold Inc., is currently involved in several gold mining ventures in Nevada. These are a 100 per cent interest in Relief Canyon Mine, 26.25 per cent in Pinson Mine and 29.3 per cent in Dee Gold Mine, all of which are heap leach operations.

Pegasus Gold Ltd. and Wharf Resources Ltd. are both involved in heap leaching operations in the United States. This type of mining represents about 15 per cent of the country's gold production.

Asamera Minerals (51 per cent) and Breakwater Resources (49 per cent) expect to have the Cannon Gold Mine outside of Wenatchee, Washington in production by 1985. A 250 m shaft is being sunk to obtain access to ore reserves of about 6 million t grading about 7.78 g/t. The company estimates a 20 year life at a milling rate of 2 000 tpd.

Exploration activity in Australia has been similar to that in Canada in that known gold producing areas are being intensively examined. Since 1981 five major mines in western Australia alone have been brought back into production including: Paringa-Kalgoorlie by Gold Resources Pty. in 1983 with 1.31 million t of ore grading 6.3 g/t, Lancefield Mine by Western Mining Corp. in 1982 with 460 000 t of ore grading 6.2 g/t; Horseshoe Lights by a consortium, with 1.3 million t grading 4 g/t; Griffins Find by Otter Explorations Ltd. based on 600 000 t at 3.7 g/t; and Mt. Magnet reopened by Hill 50 NL based on 1.04 million t grading 8.3 g/t.

Esso Exploration and Production Australia has received the go ahead for its Harbour Lights joint venture. Full production is expected by mid-1985 at a rate of 2 000 kg of gold per year, based on 5.5 million t grading 4 g/t.

The Kidson Gold Mine is expected to begin operation in early-1985 at an annual rate of 6 100 kg of gold and 4 850 kg of silver. Production costs have been estimated at $A 226 per oz of gold.

Gold mining at the Ok Tedi gold-copper mine in Papua-New Guinea, which started up in mid-1984, was hampered by several short closures due to untreated tailings spillages and an accident which involved a spill of sodium cyanide. Production has resumed at 17 000 tpd of ore with a planned increase to 22 500 tpd. Bearing further shutdowns first year production is expected to be about 18 000 to 20 000 kg of gold. Ok Tedi is a consortium project involving BHP Minerals (30 per cent), Amoco Minerals (PNG) (30 per cent), Papua-New Guinea government (20 per cent) and a West German consortium (20 per cent).

## PRICES

Gold averaged $US 424.18 per oz during 1983 on the LME. The price started the year in a strong position of $US 481 in January strengthened to $US 491 in February then subsequently fell over $US 100 per oz and finished the year at $US 383 per oz.

The price fared even worse in 1984 with an average of $US 360 per oz. The price remained relatively strong until mid-year when the average monthly price fell from $US 378 to $US 347 between June and July. The monthly average stayed above $US 340 per oz until December when the price fell to $US 319.

## CONSUMPTION AND USES

The use of new gold for jewellery, coin and industrial purposes declined in 1983 in the western world to 1 002 t from 1 073 t in 1982. Poor economic conditions in many parts of the world, combined with the effects of a strengthening U.S. dollar, were mainly responsible for the consumption decrease. The combination of these factors reduced jewellery fabrication in all regions except North America, Japan and the Middle East.

After gaining in 1981 and 1982, demand for new gold for jewellery fell 16 per cent in 1983 to 599 t. Jewellery consumption may be divided into demand by industrialized nations where it is a luxury item and by developing countries where it is often a form of savings and investment. In industrialized countries fabrication declined 9 per cent to 383 t and in developing countries the decline was 27 per cent to 215 t.

The consumption of gold in electronic components increased by 14 per cent to 96.4 t in 1983. The largest improvements occurred in Japan and the United States. While the electronics industry has cut its gold consumption per electronic unit, stronger consumer sales of equipment such as videos and home computers offset unit reductions. In addition, development of new electronic products has resulted in the expansion of the applications for gold.

Worldwide demand for gold for use in dental alloys diminished from 60 t in 1982 to 53 t in 1983. The gold content of dental alloys has been reduced over the years, primarily due to the relatively high price for gold, despite the fact that the new alloys are harder to work with and have a shorter useful life.

The use of gold in various miscellaneous applications such as decorative plating, liquid gold for decoration of glass and ceramics, rolled gold and various industrial chemicals declined by about 7 per cent from 620 t in 1982 to 58 t in 1983. The main factors contributing to the decline are the continued substitution of rolled gold by plating on such articles as pens and the replacement of gold brazing alloys by nickel alloys in jet engines. A relatively recent new application for gold which has gained some acceptance is the use of gold in windows, as protection against light and heat.

Production of gold medals, medallions and other coins dropped to 34 t in 1983 from 56 t in 1982. Sales of the American Arts medallions being minted in the United States have been disappointing since the public appears to view the medallions as collectable items and not as investments such as the Canadian Maple Leaf or the Krugerrand.

The sales of Canadian Gold Maple Leaf coins rose by 8 per cent in 1983 and a steady market appears to have been established in the United States, Japan and Europe. This coin may pick up market share as some countries ban or impede the sale of South African Krugerrands.

Investment demand includes jewellery purchases (in developing countries), hoarding of bars and bullion coins, and investor demand which include future trading as well as metal purchases on account. In 1983 the sale of bars fell by 73 per cent to 81.4 t from 303.2 t in 1982. Various factors have exerted an adverse influence on attitudes towards gold as a potential investment including the strong U.S. dollar which has kept the gold price at a high level in terms of other currencies, and attractiveness of investing in U.S. dollars.

## OUTLOOK

The short-term outlook for gold is for continued weakness and a rather lacklustre performance through 1985. Based on recent past performance it seems that the continued strength of the U.S. dollar along with higher real interest rates and low inflation expectations will divert much of the investment interest away from gold. As well, the decline in the price of oil has both diminished the purchases of gold by OPEC nations and has also precipitated sales of gold which were bought in the 1970s.

Despite the current low price for gold, many countries will be increasing their gold output in the near future, namely Canada, Australia, Brazil and the United States. Newly applied technologies such as heap leaching have made numerous large low-grade gold deposits economically viable.

In Canada gold production is expected to increase substantially as the Hemlo gold producers come on-stream. In addition the current high level of gold exploration will likely result in additional gold mines being developed. Table 6 indicates a forecast of future growth in Canadian gold production.

### TABLE 1. CANADA, GOLD PRODUCTION AND TRADE, 1982-84

| | 1982 | 1983 | 1984 |
|---|---|---|---|
| | | (grams) | |
| **Production** | | | |
| Newfoundland | | | |
| Base-metal mines | 140 978 | 10 000 | 186 600 |
| New Brunswick | | | |
| Base-metal mines | 204 938 | 142 000 | 501 500 |
| Quebec | | | |
| Auriferous quartz mines | | | |
| Bourlamaque-Louvicourt | 4 558 818 | 4 157 000 | |
| Malartic, Matagami and Chibougamau[1] | 14 895 307 | 16 110 000 | |
| Total | 19 454 125 | 20 267 000 | |
| Base-metal mines | 6 376 846 | 5 716 000 | |
| Total Quebec | 25 830 971 | 25 983 000 | 29 282 000 |
| Ontario | | | |
| Auriferous quartz mines | | | |
| Larder Lake[2] | 3 447 365 | 3 610 000 | |
| Porcupine[3] | 7 389 293 | 8 497 000 | |
| Red Lake and Patricia | 8 110 798 | 8 086 000 | |
| Total | 18 947 456 | 20 193 000 | |
| Base-metal mines | 1 119 960 | 1 427 000 | |
| Total Ontario | 20 067 416 | 21 620 000 | 26 472 000 |
| Manitoba-Saskatchewan | | | |
| Auriferous quartz mines | 343 700 | 157 000 | |
| Base-metal mines | 1 656 399 | 2 256 000 | |
| Total Manitoba-Saskatchewan | 2 000 099 | 2 413 000 | 2 060 000 |
| Alberta | | | |
| Placer operations | 10 836 | 21 000 | 2 800 |
| British Columbia | | | |
| Auriferous quartz mines | 3 007 042 | 3 671 000 | |
| Base-metal mines | 4 527 670 | 4 733 000 | |
| Placer operations | 175 607 | 17 000 | |
| Total British Columbia | 7 710 319 | 8 421 000 | 7 550 000 |
| Yukon | | | |
| Base-metal mines | 366 313 | 514 000 | |
| Placer operations | 2 290 025 | 2 494 000 | |
| Total Yukon | 2 656 338 | 3 008 000 | 2 700 000 |
| Northwest Territories | | | |
| Auriferous quartz mines | 6 113 335 | 9 128 000 | 12 600 000 |
| Canada | | | |
| Auriferous quartz mines | 47 865 658 | 53 416 000 | |
| Base-metal mines | 14 393 104 | 14 798 000 | |
| Placer operations | 2 476 468 | 2 532 000 | |
| Total | 64 735 230 | 70 746 000 | 81 350 900 |
| Total value ($) | 968,012,000 | 1,186,411,000 | 1,227,846,688 |
| Average value per oz[4] ($) | 465.19 | 521.60 | 469.66 |

TABLE 1. (cont'd)

| | 1982 | | 1983 | | 1984 | |
|---|---|---|---|---|---|---|
| | (kilograms) | ($000) | (kilograms) | ($000) | (kilograms) | ($000) |
| **Imports** | | | | | (Jan.-Sept.) | |
| Gold in ores and concentrates | | | | | | |
| United States | 382 | 4,579 | 773 | 9,984 | 325 | 4,739 |
| Peru | 19 | 201 | 143 | 2,177 | 66 | 895 |
| South Korea | 24 | 380 | 2 | 31 | - | - |
| Chile | - | - | - | - | 112 | 1,490 |
| Other countries | 20 | 248 | - | - | 36 | 574 |
| Total | 445 | 5,408 | 918 | 12,192 | 539 | 7,648 |
| Gold | | | | | | |
| United States | 21 141 | 337,004 | 38 788 | 668,938 | 36 405 | 573,924 |
| Switzerland | 3 881 | 57,331 | 1 740 | 30,470 | 711 | 10,709 |
| United Kingdom | 20 | 346 | 641 | 10,497 | - | - |
| U.S.S.R. | - | - | 200 | 3,320 | - | - |
| West Germany | 79 | 1,223 | 139 | 2,393 | 201 | 3,095 |
| Other countries | 145 | 2,222 | 93 | 1,560 | 39 | 710 |
| Total | 25 266 | 398,126 | 41 601 | 717,178 | 37 356 | 588,440 |
| Gold alloys | | | | | | |
| United States | 20 055 | 254,402 | 13 086 | 218,734 | 7 271 | 102,977 |
| Peru | 329 | 5,076 | 2 444 | 38,641 | 1 900 | 29,760 |
| Costa Rica | - | - | 3 538 | 24,477 | - | - |
| Nicaragua | 4 806 | 20,762 | 3 220 | 20,719 | 3 199 | 15,429 |
| Uraguay | - | - | 1 637 | 19,770 | - | - |
| Other countries | 1 233 | 18,535 | 497 | 5,505 | 175 | 1,739 |
| Total | 26 423 | 298,775 | 24 422 | 327,846 | 12 545 | 149,400 |
| **Exports** | | | | | | |
| Gold in ores and concentrates | | | | | | |
| Japan | 3 059 | 31,086 | 3 552 | 45,346 | 2 595 | 30,632 |
| United States | 736 | 9,843 | 1 401 | 19,848 | 870 | 12,414 |
| Taiwan | 196 | 1,708 | 376 | 4,683 | 13 | 152 |
| Switzerland | - | - | 337 | 4,352 | 112 | 1,283 |
| Other countries | 1 049 | 10,810 | 607 | 7,448 | 627 | 8,041 |
| Total | 5 040 | 53,447 | 6 273 | 81,677 | 4 217 | 52,322 |
| Gold | | | | | | |
| United States | 81 264 | 1,213,652 | 7 415 | 1,244,130 | 77 876 | 1,213,417 |
| Japan | 570 | 7,621 | 2 288 | 28,276 | 8 354 | 127,654 |
| Hong Kong | 57 | 1,007 | 546 | 7,908 | 825 | 12,530 |
| Singapore | 501 | 8,098 | 444 | 7,490 | 250 | 7,058 |
| West Germany | 4 | 42 | 449 | 7,254 | 445 | 7,580 |
| Other countries | 4 341 | 65,904 | 491 | 8,577 | 797 | 6,915 |
| Total | 86 737 | 1,296,324 | 78 368 | 1,303,635 | 88 247 | 1,372,157 |

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Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Includes Mines D'Or Lac Bachelor. [2] Includes Thunderbay area. [3] Includes Sudbury area. [4] Average of London Gold Market afternoon fixings in Canadian funds.
- Nil.

## TABLE 2. CANADA, GOLD PRODUCTION BY SOURCE, 1970, 1975 AND 1979-83

| | Auriferous Quartz Mines | | Placer Operations | | Base-Metal Ores | | Total | |
|---|---|---|---|---|---|---|---|---|
| | (grams) | (%) | (grams) | (%) | (grams) | (%) | (grams) | (%) |
| 1970 | 58 591 610 | 78.2 | 228 890 | 0.3 | 16 094 525 | 21.5 | 74 915 025 | 100.0 |
| 1975 | 37 529 456 | 73.0 | 335 077 | 0.6 | 13 568 581 | 26.4 | 51 433 114 | 100.0 |
| 1979 | 33 794 332 | 66.1 | 899 202 | 1.7 | 16 448 825 | 32.2 | 51 142 359 | 100.0 |
| 1980 | 31 928 594 | 63.1 | 2 059 727 | 4.0 | 16 631 942 | 32.9 | 50 620 263 | 100.0 |
| 1981 | 35 876 992 | 69.0 | 1 632 720 | 3.1 | 14 524 569 | 27.9 | 52 034 281 | 100.0 |
| 1982 | 47 865 658 | 74.0 | 2 476 468 | 3.8 | 14 393 104 | 27.2 | 64 735 230 | 100.0 |
| 1983P | 53 416 000 | 75.5 | 2 532 000 | 3.6 | 14 798 000 | 20.9 | 70 746 000 | 100.0 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary.

## TABLE 3. CANADA, GOLD PRODUCTION, AVERAGE VALUE PER GRAM AND RELATIONSHIP TO TOTAL VALUE OF ALL MINERAL PRODUCTION[1], 1970, 1975 AND 1979-83

| | Total Production | Total Value | Average Value per Gram[1] | Gold as per cent of Total Value of Mineral Production |
|---|---|---|---|---|
| | (grams) | ($ Cdn) | ($ Cdn) | (%) |
| 1970 | 74 915 025 | 88,057,464 | 1.18 | 1.5 |
| 1975 | 51 433 114 | 270,830,389 | 5.27 | 2.0 |
| 1979 | 51 142 359 | 590,766,328 | 11.55 | 2.3 |
| 1980 | 50 620 263 | 1,165,416,873 | 23.02 | 3.7 |
| 1981 | 52 034 281 | 922,089,087 | 17.72 | 2.9 |
| 1982 | 64 735 230 | 968,012,000 | 14.95 | 2.9 |
| 1983P | 70 746 000 | 1,186,411,000 | 16.77 | 3.3 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Value not necessarily based on average annual gold price.
P Preliminary.

**TABLE 4. GOLD MINE PRODUCTION IN THE NON-COMMUNIST WORLD**

| | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | (tonnes) | | | | |
| South Africa | 855.2 | 758.6 | 713.4 | 713.4 | 699.9 | 706.4 | 705.4 | 675.1 | 657.6 | 664.3 | 679.7 |
| Canada | 60.0 | 52.2 | 51.4 | 52.4 | 54.0 | 54.0 | 51.1 | 50.6 | 52.0 | 62.5 | 70.7 |
| United States | 36.2 | 35.1 | 32.4 | 32.2 | 32.0 | 31.1 | 29.8 | 30.2 | 42.5 | 43.5 | 50.4 |
| Other Africa: | | | | | | | | | | | |
| Ghana | 25.0 | 19.1 | 16.3 | 16.6 | 16.9 | 14.2 | 11.5 | 10.8 | 11.6 | 12.0 | 11.8 |
| Zimbabwe | 10.5 | 10.4 | 11.0 | 12.0 | 12.5 | 12.4 | 12.0 | 11.4 | 11.6 | 13.4 | 14.1 |
| Other | 1.7 | 1.5 | 1.5 | 1.5 | 1.5 | 2.0 | 2.5 | 8.0 | 12.0 | 15.0 | 15.0 |
| Zaire | 2.5 | 4.4 | 3.6 | 4.0 | 3.0 | 1.0 | 2.3 | 3.0 | 3.2 | 4.2 | 6.0 |
| Total Other Africa | 39.7 | 35.4 | 32.4 | 34.1 | 33.9 | 29.6 | 28.3 | 33.2 | 38.4 | 44.6 | 46.9 |
| Latin America: | | | | | | | | | | | |
| Brazil | 11.0 | 13.8 | 12.5 | 13.6 | 15.9 | 22.0 | 25.0 | 35.0 | 35.0 | 34.8 | 51.0 |
| Colombia | 6.7 | 8.2 | 10.8 | 10.3 | 9.2 | 9.0 | 10.0 | 17.0 | 17.7 | 15.5 | 17.9 |
| Dominican Republic | - | - | 3.0 | 12.7 | 10.7 | 10.8 | 11.0 | 11.5 | 12.8 | 11.8 | 10.8 |
| Chile | 3.2 | 3.7 | 4.1 | 3.0 | 3.0 | 3.3 | 4.3 | 6.5 | 12.2 | 18.9 | 19.8 |
| Other | 4.7 | 2.2 | 1.9 | 5.0 | 5.0 | 5.2 | 3.7 | 5.9 | 8.1 | 9.0 | 16.5 |
| Peru | 2.6 | 2.7 | 2.9 | 3.0 | 3.4 | 3.9 | 4.7 | 5.0 | 7.2 | 7.2 | 9.9 |
| Mexico | 4.2 | 3.9 | 4.7 | 5.4 | 6.7 | 6.2 | 5.5 | 5.9 | 5.0 | 5.2 | 6.3 |
| Nicaragua | 2.8 | 2.4 | 1.9 | 2.0 | 2.0 | 2.3 | 1.9 | 1.5 | 1.6 | 2.9 | 1.7 |
| Total Latin America | 35.2 | 36.9 | 41.8 | 55.0 | 55.9 | 62.7 | 66.1 | 88.3 | 99.6 | 105.3 | 133.9 |
| Asia: | | | | | | | | | | | |
| Philippines | 18.1 | 17.3 | 16.1 | 16.3 | 19.4 | 20.2 | 19.1 | 22.0 | 24.9 | 26.0 | 33.3 |
| Japan | 6.2 | 4.5 | 4.7 | 4.6 | 4.8 | 4.9 | 4.4 | 4.2 | 3.5 | 3.8 | 3.6 |
| India | 3.3 | 3.2 | 3.0 | 3.3 | 2.9 | 2.8 | 2.7 | 2.6 | 2.6 | 2.2 | 2.2 |
| Other | 2.7 | 2.7 | 2.7 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.8 | 3.6 | 5.3 |
| Total Asia | 30.3 | 27.7 | 26.5 | 27.2 | 30.1 | 30.9 | 29.2 | 31.8 | 34.8 | 35.6 | 44.4 |
| Europe | 14.3 | 11.6 | 11.0 | 11.4 | 13.2 | 12.5 | 10.0 | 8.6 | 8.5 | 10.6 | 10.0 |
| Oceania: | | | | | | | | | | | |
| Papau/New Guinea | 20.3 | 20.5 | 17.9 | 20.5 | 22.3 | 23.4 | 19.7 | 14.3 | 17.2 | 17.8 | 18.4 |
| Australia | 17.2 | 16.2 | 16.3 | 15.4 | 19.2 | 20.1 | 18.6 | 17.0 | 18.4 | 27.4 | 32.2 |
| Other | 2.8 | 2.2 | 2.2 | 2.3 | 1.8 | 1.1 | 1.0 | 1.0 | 1.1 | 1.2 | 1.6 |
| Total Oceania | 40.3 | 38.9 | 36.4 | 38.2 | 43.3 | 44.6 | 39.3 | 32.3 | 36.7 | 46.4 | 52.2 |
| TOTAL | 1 111.2 | 996.4 | 945.3 | 963.9 | 962.3 | 971.8 | 959.2 | 950.1 | 970.1 | 1 012.8 | 1 088.2 |

Source: Consolidated Gold Fields PLC, Gold 1983, p. 12.
- Nil.

## TABLE 5. AVERAGE ANNUAL PRICE OF GOLD, 1970, 1975 AND 1979-83

| | London Gold Market[1] | |
|---|---|---|
| | $US | equiv. $Cdn (per troy ounce) |
| 1970 | 35.97 | 37.55 |
| 1975 | 161.018 | 163.781 |
| 1979 | 306.686 | 359.289 |
| 1980 | 612.562 | 716.087 |
| 1981 | 459.715 | 551.178 |
| 1982 | 376.877 | 465.102 |
| 1983 | 422.600 | 520.792 |

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[1] Annual average of London Gold Market afternoon fixing price, as reported by Sharpes Pixley Ltd.

## TABLE 6. ANNUAL GOLD PRODUCTION FORECAST

| | Non-communist World[1,2] | Canadian |
|---|---|---|
| | (tonnes) | |
| 1979 | 1 153.9 | 51.1 |
| 1980 | 1 029.5 | 50.6 |
| 1981 | 1 234.8 | 52.5 |
| 1982 | 1 231.7 | 64.7 |
| 1983 | 1 265.9 | 73.5 |
| 1984 | 1 280.0P | 81.3P |
| 1985 | 1 310.0f | 82.0f |
| 1986 | 1 315.0 | 84.0 |
| 1987 | 1 315.0 | 87.0 |
| 1988 | 1 310.0 | 85.0 |
| 1989 | 1 310.0 | 85.0 |
| 1990 | 1 310.0 | 87.0 |
| 1991 | 1 290.0 | 90.0 |
| 1992 | 1 290.0 | 90.0 |
| 1993 | 1 270.0 | 85.0 |
| 1994 | 1 270.0 | 85.0 |
| 1995 | 1 270.0 | 85.0 |
| 1996 | 1 250.0 | 80.0 |
| 1997 | 1 250.0 | 80.0 |
| 1998 | 1 250.0 | 75.0 |
| 1999 | 1 250.0 | 75.0 |
| 2000 | 1 250.0 | 75.0 |

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[1] Mine production; does not include recycled material. [2] Market economy country production plus sales from East Bloc Countries.
P Preliminary; f Forecast.

# Gypsum and Anhydrite

D.H. STONEHOUSE

## SUMMARY 1983-1984

During the last quarter of 1982, demand for gypsum wallboard by the building construction industry in the United States continued to increase in evidence of that country's recovery from the recessionary conditions of the previous two years. To meet that demand, wallboard producers required greater than usual amounts of crude gypsum from their Canadian subsidiary operations. The trend continued throughout 1983 and 1984 with the result that Canadian exports of gypsum to the United States were up by 9 per cent in 1983 and are expected to increase a further 25 per cent during 1984. Canadian wallboard producers also benefitted from the United States demand for board and increased their output by over 30 per cent to 200 million square metres in 1983 while exports to the United States rose by 84 per cent to 36.5 million square metres. Wallboard exports, mainly from Ontario and Quebec plants, are expected to increase by over 200 per cent during 1984.

## CANADIAN DEVELOPMENTS

Gypsum production in Canada is in direct response to demand from the wallboard industries in Canada and the United States, which in turn satisfy demand from the building construction sector for residential, institutional and commercial construction projects. The fire retardant qualities of gypsum wallboard have encouraged its greater application in the non-residential area in recent years. This, together with increasing amounts used in renovation of older buildings, has made housing starts a less-than-accurate indicator of wallboard demand.

The portland cement industry uses as much as 5 per cent by weight of gypsum intimately ground with cement clinker to act as a set inhibitor. This could amount to nearly 0.5 million tpy in Canada.

Canadian production of crude gypsum is mainly from Atlantic Canada where major deposits, principally in Nova Scotia and Newfoundland, have been worked for many years by Canadian subsidiaries of U.S. gypsum products producers. The region accounts for over 75 per cent of Canadian gypsum production and for the major portion of exported gypsum which usually is about 70 per cent of total production; however nearly 80 per cent of production will be exported in 1984. Shipments are made from quarries in the Atlantic region to wallboard plants and portland cement plants in Quebec and Ontario. New Brunswick production is used locally by a cement producer. Ontario production is used on-site except that from the Westroc Industries Limited mine at Drumbo which is shipped to its Mississauga wallboard plant. Manitoba production, and output from Windermere and Falkland in British Columbia, supply the prairie markets and most of the British Columbia markets. Imports from Mexico and the United States are used by both wallboard and cement producers in British Columbia.

Because gypsum is a relatively low-cost, high-bulk mineral commodity it is generally produced from deposits situated as conveniently as possible to areas in which markets for gypsum products exist. Exceptions occur if deposits of unusually high quality are available, even at some distance from markets, if comparatively easy and inexpensive mining methods are applicable, or if low-cost, high-bulk shipping facilities are accessible. Nova Scotia and Newfoundland deposits meet all three of these criteria and have been operated for many years by, and for, United States companies in preference to some known but unexploited United States deposits. During 1984, Little Narrows Gypsum Company Limited and Georgia Pacific Corporation each began development of new quarry areas.

In Canada occurrences besides those currently being exploited are known in the southwest lowlands, west of the Long Range Mountains in Newfoundland; throughout the central and northern mainland of Nova Scotia as well as on Cape Breton Island; in the southeastern counties of New Brunswick; on

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the Magdalen Islands of Quebec; in the Moose River, James Bay and southwestern regions of Ontario; in Wood Buffalo National Park, in Jasper National Park, along the Peace River between Peace Point and Little Rapids, and north of Fort Fitzgerald in Alberta; on Featherstonhaugh Creek, near Mayook, at Canal Flats, and Loos in British Columbia; on the shores of Great Slave Lake, the Mackenzie, Great Bear and Slave rivers in the Northwest Territories; and on several Arctic islands.

There was no change in the number of producing mines or plants in 1983. Eleven open-pit mines and two underground mines produced about 7.5 million t in total. Gypsum products were produced at 17 plants. During the year, CGC Inc. and Westroc Industries Limited jointly announced that a merger of the two companies had been arranged through the respective parent companies - United States Gypsum Company (U.S.G.) and British Plaster Board Industries Limited. U.S.G. was to own 70 per cent of the new company. Initial inquiries were made at the Foreign Investment Review Agency in May 1983 and when no decision was made by October both companies withdrew their request for a ruling on a merger. United States Gypsum Company sold the roofing business of its subsidiary, CGC Inc., to Canroof Corp. in 1983. Plants are in Montreal, Toronto and Winnipeg.

In 1981, Domtar Inc. purchased the inactive mine and wallboard plant of Grand Rapids Gypsum Company in Michigan. The increased demand for wallboard prompted Domtar to reopen the operation and to install new rock grinding facilities. The plant has a capacity of over 11 million square metres of board a year.

The demand for wallboard provided CGC Inc. with incentive to reopen its St. Jerome, Quebec plant in early 1984 after a 20-month closure because of poor domestic markets. Domtar Inc. did not reactivate its Montreal East plant as the capacity of the new plant at the Caledonia, Ontario minesite is adequate to meet foreseeable requirements. The Montreal East plant serves as a distribution terminal for all eastern Canadian shipments.

## WORLD DEVELOPMENTS AND TRADE

Gypsum occurs in abundance throughout the world but, because its use is dependent on the building construction industry, developments are generally limited to the industrialized countries. Reserves are extremely large and are conservatively estimated at over 2 billion t. After the United States, Canada is the world's second largest producer of natural-gypsum. Together they produce about 24 per cent of world output.

During 1984 shipments of crude gypsum were made from Spain to eastern and western United States ports.

Gypsum products, particularly wallboard, have limited market range because of high unit weight, friability, high transportation costs and relatively low unit values. These factors generally dictate that markets are supplied from the closest producer. There are exceptions, however, and gypsum wallboard has been shipped not only between the United States and Canada over rather surprisingly great distances but shiploads of wallboard have been received at United States southeast ports from European producers. The Canada-United States trade is usually in truckload lots of 20 to 25 t for delivery to warehousing or to job sites.

Imports of crude gypsum, mainly into British Columbia from Mexico and the United States were between 100 000 t and 125 000 t during 1983 and 1984. Imports of wallboard and gypsum products increased to close to 500 000 square metres ($m^2$) in 1983 from about 350 000 $m^2$ in 1982, but declined to just over 200 000 $m^2$ in 1984.

## USES

Gypsum is a hydrous calcium sulphate ($CaSO_4.2H_2O$) which, when calcined at temperatures ranging from 120° to 205°C, releases three-quarters of its chemically combined water. The resulting hemihydrate of calcium sulphate, commonly referred to as plaster of paris, when mixed with water, can be moulded, shaped or spread and subsequently dried, or set, to form a hard plaster product. Gypsum is the main mineral constituent in gypsum wallboard, lath and tile. Anhydrite, an anhydrous calcium sulphate ($CaSO_4$), is commonly associated geologically with gypsum.

Crude gypsum is crushed, pulverized and calcined to form stucco, which is mixed with water and aggregate (sand, vermiculite or expanded perlite) and applied over wood, metal or gypsum lath to form interior wall finishes. Gypsum board, lath and sheathing are formed by introducing a slurry of stucco, water, foam, pulp and starch between two unwinding rolls of absorbent paper, the result is a continuous "sandwich" of wet board. As the stucco hardens, the board is cut to predetermined lengths, dried, bundled and stacked for shipment.

Grinding, calcining and drying are the main energy-using steps in the manufacture of gypsum wallboard. In the interests of energy conservation and process cost reduction in general, significant savings have been achieved by recycling heat from calcining kettles for use in preheating and in board drying. One-step grinding and calcining as an alternative to either the batch kettle or the continuous kettle has been adopted by one producer. There is also a trend towards using less calcined gypsum in board while using greater amounts of foam and more effective dispersing agents to obtain a lighter-weight unit with equal or greater strength.

Keene's cement is made by converting crushed gypsum to insoluble anhydrite by calcining at temperatures as high as 700°C, usually in rotary kilns. The ground calcine, mixed with a set accelerator, produces a harder and stronger plaster product than ordinary gypsum plaster.

Crude gypsum is also used in the manufacture of portland cement where it acts as a retarder to control set. It is used as a filler in paint and paper manufacture, as a substitute for salt cake in glass manufacture and as a soil conditioner.

Byproduct gypsum, produced from the acidulation of phosphate rock in phosphate fertilizer manufacture, has not been utilized in Canada despite available technology from European countries and from Japan. In these countries, byproduct gypsum is used in the manufacture of gypsum products, by cement manufacturing plants, and also for soil stabilization. Recent experiments in France have produced paper with a 20 per cent phosphogypsum content as filler. Studies have indicated that a potential radiation hazard exists in the use of phosphogypsum produced from sedimentary phosphate rock which can contain significant quantities of uranium and radium. Fluorogypsum is a byproduct of the manufacture of hydrofluoric acid. Cooperative research programs have been conducted to determine the suitability of using waste fluorogypsum from Allied Chemical Canada Ltd.'s, Amherstburg, Ontario plant at St. Lawrence Cement Inc.'s Clarkson, Ontario cement plant.

The use of lime or limestone to desulphurize stack gases from utility or industrial plants burning high-sulphur fuel will also result in production of large amounts of waste gypsum in the form of a sludge which will present disposal problems if profitable uses are not developed.

Canadian Standards Association (CSA) standards A 82.20 and A 82.35 relate to gypsum and gypsum products.

## OUTLOOK

Total construction in Canada in 1983 was valued at $56 billion, about the same as in 1982. This is expected to increase to $56.9 billion for 1984. Building construction is expected to account for a traditional 54.5 per cent of total value as recovery in the residential building sector offsets declines in the industrial and commercial sectors. Housing starts increased to 162,645 units in 1983 from a low 125,860 in 1982 but will be in the 133,000 range for 1984. Construction of homes, apartments, schools and offices will continue in the building construction sector and the need for gypsum-based building products will rise steadily. Although new construction materials are being introduced, gypsum wallboard will remain popular because of its low price, ease of installation and well-recognized insulating and fire-retarding properties. The present structure of the gypsum industry in Canada is unlikely to change greatly in the near future. Building materials plants have sufficient capacities to meet the short-term, regional demand for products and to supply at least some of the unusually high demand from the United States.

The Canadian Construction Association (CCA) predicts above average growth in the non-residential sector in the near term followed by average growth in engineering and non-residential projects in the medium term. CCA predicts no growth in the residential sector in the medium to long term.

## ANHYDRITE

Production and trade statistics for anhydrite are included with gypsum statistics. Anhydrite is produced by Fundy Gypsum Company Limited at Wentworth, Nova Scotia, and by Little Narrows Gypsum Company Limited at Little Narrows, Nova Scotia. According to the **Nova Scotia Annual Report on Mines 1983,** production of anhydrite in that year was 108 807 t. Most of this was shipped to the United States for use in portland cement manufacture and as a peanut crop fertilizer. Cement plants in Quebec and Ontario also used some Nova Scotia anhydrite.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| **CANADA** | | | | | |
| 29200-1 | Gypsum, crude | free | free | free | free |
| 29300-1 | Plaster of paris, or gypsum, calcined, and prepared wall plaster, weight of package to be included in weight for duty; per hundred pounds | free | 5.0¢ | 12.5¢ | free |
| 29400-1 | Gypsum, ground, not calcined | free | free | 15% | free |
| 28410-1 | Gypsum tile | 12.8% | 12.1% | 25% | 8.0% |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| 29300-1 | 5.0¢ | 4.8¢ | 4.5¢ | 4.3¢ | 4.0¢ |
| 28410-1 | 12.1% | 11.4% | 10.7% | 9.9% | 9.2% |

UNITED STATES (MFN)

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| 512.21 | Gypsum crude | free | | | | |
| 512.24 | Gypsum, ground calcined, per ton | 50¢ | 48¢ | 46¢ | 44¢ | 42¢ |
| 245.70 | Gypsum or plastic building boards and lath, ad valorem | 4.2% | 3.8% | 3.3% | 2.9% | 2.5% |

Sources: The Customs Tariff, 1983, Revenue Canada, Custom and Excise; Tariff Schedules of the United States Annotated (1983), USITC Publication 1317; U.S. Federal Register, Vol. 44, No. 241.

TABLE 1. CANADA, GYPSUM PRODUCTION AND TRADE, 1982-84

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Production** (shipments) | | | | | | |
| Crude gypsum | | | | | | |
| Nova Scotia | 4 480 000 | 30,500 | 5 397 000 | 37,064 | 6 461 000 | 43,677 |
| Ontario | 574 000 | 5,350 | 907 000 | 11,354 | 1 104 000 | 13,408 |
| British Columbia | 415 000 | 5,468 | 460 000 | 4,917 | 504 000 | 4,859 |
| Newfoundland | 409 000 | 3,284 | 553 000 | 3,731 | 430 000 | 3,610 |
| Manitoba | 109 000 | 2,006 | 190 000 | 2,231 | 226 000 | 3,600 |
| Total | 5 987 000 | 46,608 | 7 507 000 | 59,297 | 8 725 000 | 69,154 |
| | | | | | (Jan.-Sept. 1984) | |
| **Imports** | | | | | | |
| Crude gypsum | | | | | | |
| Spain | - | - | - | - | 83 914 | 2,876 |
| Mexico | 83 102 | 2,806 | 97 444 | 2,949 | 34 343 | 1,090 |
| United States | 10 742 | 264 | 3 479 | 128 | 3 510 | 81 |
| Hong Kong | - | - | 16 | 1 | 57 | 2 |
| Total | 93 844 | 3,069 | 100 939 | 3,078 | 121 824 | 4,049 |
| Plaster of paris and wall plaster | | | | | | |
| United States | 18 627 | 3,654 | 24 717 | 4,630 | 16 480 | 3,385 |
| France | 175 | 34 | - | - | 12 | 1 |
| United Kingdom | 15 | 3 | - | - | 20 | 4 |
| Italy | 16 | 3 | - | - | 6 | 2 |
| Other countries | 93 | 30 | 11 | 3 | 3 | 1 |
| Total | 18 926 | 3,724 | 24 728 | 4,633 | 16 521 | 3,393 |
| | (square metres) | | (square metres) | | (square metres) | |
| Gypsum lath, wallboard and basic products | | | | | | |
| United States | 349 862 | 643 | 485 614 | 722 | 227 391 | 522 |
| Other countries | - | - | 5 942 | 8 | - | - |
| Total | 349 862 | 643 | 491 556 | 730 | 227 391 | 522 |
| Total imports gypsum and gypsum products | | 7,436 | | 8,441 | | 7,964 |
| | (tonnes) | | (tonnes) | | (tonnes) | |
| **Exports** | | | | | | |
| Crude gypsum | | | | | | |
| United States | 4 775 780 | 28,716 | 5 186 529 | 33,331 | 4 839 315 | 37,494 |
| Other | - | - | 503 | 6 | 1 022 | 8 |
| Total | 4 775 780 | 28,716 | 5 187 032 | 33,337 | 4 840 337 | 37,502 |
| | (square metres) | | (square metres) | | (square metres) | |
| Gypsum lath, wallboard and basic products | | | | | | |
| United States | 13 808 620 | 12,898 | 25 836 909 | 28,435 | 55 025 773 | 78,075 |
| Saudi Arabia | 224 507 | 576 | 154 418 | 485 | 60 853 | 189 |
| Algeria | 31 639 | 46 | 195 192 | 189 | 121 991 | 236 |
| Bermuda | 111 219 | 139 | 70 344 | 114 | 60 306 | 76 |
| Other countries | 209 016 | 261 | 223 072 | 296 | 224 937 | 416 |
| Total | 14 385 001 | 13,920 | 26 479 935 | 29,519 | 55 513 860 | 78,992 |
| Total exports of gypsum and gypsum products | | 42,636 | | 62,856 | | 116,494 |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
P Preliminary; - Nil.
N.B. Totals may not add due to rounding.

TABLE 2. CANADA, GYPSUM MINING AND GYPSUM PRODUCTS MANUFACTURING OPERATIONS, 1983-84

| Company | Location | Operation |
|---|---|---|
| Newfoundland | | |
| Flintkote Holdings Limited | Flat Bay | Open-pit mining of gypsum |
| Atlantic Gypsum Limited | Corner Brook | Wallboard manufactors |
| Nova Scotia | | |
| Domtar Inc. | McKay Settlement | Open-pit mining of gypsum by contract |
| | Windsor | Plaster and "Gypcrete" manufacture |
| Fundy Gypsum Company Ltd. | Wentworth and Miller Creek | Open-pit mining of gypsum and anhydrite |
| Georgia-Pacific Corporation | River Denys | Open-pit mining of gypsum |
| Little Narrows Gypsum Company Limited | Little Narrows | Open-pit mining of gypsum and anhydrite |
| National Gypsum (Canada) Ltd. | Milford | Open-pit mining of gypsum |
| New Brunswick | | |
| Canada Cement Lafarge Ltd. | Havelock | Open-pit mining of gypsum for cement manufacture |
| Quebec | | |
| CGC Inc. | Montreal | Wallboard manufacture |
| | St-Jerome | Wallboard manufacture - closed mid-1982, reopened early 1984 |
| Domtar Inc. | Montreal | Wallboard plant now used only as distribution terminal |
| Westroc Industries Ltd. | Ste. Catherine d'Alexandrie | Wallboard manufacture |
| Ontario | | |
| CGC Inc. | Hagersville | Underground mining and wallboard manufacture |
| Domtar Inc. | Caledonia | Underground mining and wallboard manufacture |
| Westroc Industries Ltd. | Drumbo | Underground mining |
| | Clarkson | Wallboard manufacture |
| Manitoba | | |
| Domtar Inc. | Gypsumville | Open-pit mining |
| | Winnipeg | Wallboard manufacture |
| Westroc Industries Ltd. | Amaranth | Open-pit mining |
| | Winnipeg | Wallboard manufacture |
| Saskatchewan | | |
| Genstar Corporation | Saskatoon | Wallboard manufacture |
| Alberta | | |
| Domtar Inc. | Calgary | Wallboard and "Gypcrete" manufacture |
| Genstar Corporation | Edmonton | Wallboard manufacture |
| Westroc Industries Ltd. | Calgary | Wallboard manufacture |
| British Columbia | | |
| Domtar Inc. | Vancouver | Gypsum products manufacture |
| Genstar Corporation | Vancouver | Gypsum products manufacture |
| Westroc Industries Ltd. | Windermere | Open-pit mining |
| | Vancouver | Gypsum products manufacture |

## TABLE 3. WORLD PRODUCTION OF GYPSUM, 1982 AND 1983

| | 1982 | 1983[e] |
|---|---|---|
| | (000 tonnes) | |
| United States | 9 560 | 11 068 |
| Canada | 5 987 | 7 507 |
| France | 6 169 | 6 169 |
| U.S.S.R. | 5 443 | 5 443 |
| Spain | 5 262 | 5 352 |
| Iran | 4 990 | 4 717 |
| United Kingdom | 2 722 | 2 903 |
| West Germany | 2 268 | 2 268 |
| People's Republic of China | 3 538 | 3 538 |
| Mexico | 1 542 | 1 724 |
| Italy | 1 633 | 1 724 |
| Other market economy countries | 19 732 | 17 236 |
| Other central economy countries | 4 549 | 4 536 |
| World total | 73 395 | 74 215 |

Sources: Energy, Mines and Resources Canada; United States Bureau of Mines Mineral Commodity Summaries, January 1984.
[e] Estimated.

## TABLE 4. CANADA, GYPSUM PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975, 1979-83

| | Production[1] | Imports[2] | Exports[2] | Apparent Consumption[3] |
|---|---|---|---|---|
| | (tonnes) | | | |
| 1970 | 5 732 068 | 35 271 | 4 402 843 | 1 364 496 |
| 1975 | 5 719 451 | 55 338 | 3 691 676 | 2 083 113 |
| 1979 | 8 098 166 | 152 953 | 5 474 765 | 2 776 354 |
| 1980 | 7 336 000 | 154 717 | 4 960 240 | 2 530 477 |
| 1981 | 7 025 000 | 143 500 | 5 094 873 | 2 073 627 |
| 1982 | 5 987 000 | 93 844 | 4 775 780 | 1 305 064 |
| 1983 | 7 507 000 | 100 939 | 5 187 032 | 2 420 907 |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments, crude gypsum. [2] Includes crude and ground, but not calcined. [3] Production, plus imports, minus exports.

## TABLE 5. CANADA, HOUSE CONSTRUCTION, BY PROVINCE, 1982 AND 1983

| | Starts | | | Completions | | | Under Construction | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1982 | 1983 | % Diff. | 1982 | 1983 | % Diff. | 1982 | 1983 | % Diff. |
| Newfoundland | 2 793 | 3 281 | 17.4 | 2 331 | 3 176 | 36.2 | 3 373 | 3 494 | 3.5 |
| Prince Edward Island | 248 | 673 | 171.3 | 98 | 548 | 459.1 | 196 | 316 | 61.2 |
| Nova Scotia | 3 691 | 5 697 | 54.3 | 3 174 | 5 069 | 59.7 | 2 506 | 2 984 | 19.0 |
| New Brunswick | 1 680 | 4 742 | 182.2 | 1 427 | 3 487 | 144.3 | 1 122 | 2 346 | 109.0 |
| Total (Atlantic Provinces) | 8 412 | 14 393 | 71.1 | 7 030 | 12 280 | 74.6 | 7 197 | 9 140 | 26.9 |
| Quebec | 23 492 | 40 318 | 71.6 | 21 526 | 35 681 | 65.7 | 14 164 | 18 320 | 29.3 |
| Ontario | 38 508 | 54 939 | 42.6 | 40 437 | 55 287 | 36.7 | 31 009 | 30 243 | -2.4 |
| Manitoba | 2 030 | 5 985 | 194.8 | 1 633 | 4 076 | 149.6 | 1 149 | 3 048 | 165.2 |
| Saskatchewan | 6 822 | 7 269 | 6.5 | 5 666 | 8 090 | 42.7 | 4 583 | 3 667 | -19.9 |
| Alberta | 26 789 | 17 134 | -36.0 | 31 364 | 24 693 | -21.2 | 17 663 | 8 336 | -52.8 |
| Total (Prairie Provinces) | 35 641 | 30 388 | -14.7 | 38 663 | 36 859 | -4.8 | 23 395 | 15 051 | -35.6 |
| British Columbia | 19 807 | 22 607 | 14.1 | 26 286 | 22 901 | -12.8 | 13 290 | 12 176 | -8.3 |
| Total Canada | 125 860 | 162 645 | 29.2 | 133 942 | 163 008 | 21.7 | 89 055 | 84 930 | -4.6 |

Source: Canada Mortgage and Housing Corporation.

## TABLE 6. CANADA, VALUE OF CONSTRUCTION[1] BY TYPE, 1982-84

| | 1982 | 1983 | 1984 |
|---|---|---|---|
| | | ($ millions) | |
| **Building Construction** | | | |
| Residential | 13,581 | 16,683 | 17,240 |
| Industrial | 3,044 | 2,502 | 2,739 |
| Commercial | 7,064 | 6,228 | 5,817 |
| Institutional | 3,092 | 3,198 | 3,183 |
| Other building | 2,062 | 1,989 | 2,139 |
| Total | 28,843 | 30,600 | 31,118 |
| **Engineering Construction** | | | |
| Marine | 480 | 404 | 414 |
| Highways, airport runways | 4,310 | 4,270 | 4,328 |
| Waterworks, sewage systems | 2,244 | 2,402 | 2,391 |
| Dams, irrigation | 314 | 295 | 306 |
| Electric power | 4,866 | 4,673 | 3,827 |
| Railway, telephones | 2,390 | 2,531 | 2,811 |
| Gas and oil facilities | 9,706 | 8,115 | 9,141 |
| Other engineering | 2,912 | 2,808 | 2,635 |
| Total | 27,222 | 25,498 | 25,853 |
| Total construction | 56,065 | 56,098 | 56,971 |

Source: Statistics Canada.

[1] Actual expenditures 1982, preliminary actual 1983, intentions 1984.

# Iron Ore

B.W. BOYD

Shipments of Canadian iron ore dropped in 1983 to the lowest point since 1964 as the industry, already reduced to only nine mines, operated at less than two-thirds capacity. Partial recovery, in 1984, saw shipments rise by 25 per cent, but that was still far below the average shipments of the past 20 years.

On October 5th, 1983 Falconbridge Limited permanently closed the Wesfrob mine at Tasu, British Columbia. On October 12, 1984 Sidbec-Normines Inc. announced that the Fire Lake mine and Lac Jeannine concentrator in Quebec would close by year-end and, on December 24th, 1984 Stelco Inc. announced that the Griffith mine near Red Lake Ontario would close as of April 1986. These closures will reduce the Canadian iron ore production capacity to 49.3 million t of product at six mines. By comparison, production capacity was growing rapidly in 1964 and, with 34.5 million t shipped, the 17 mines were operating at 90 per cent of capacity.

Restructuring of the Canadian industry has, in addition to mine closures, involved a drive for higher productivity, reduction of energy costs, and research and development of new iron ore products. Total employment in the industry will have declined from a peak 16,000 established in the mid-1970s to approximatly 6,900 in April 1986. The use of coke breeze at pellet plants reduced energy costs by over 10 per cent at the largest plants in 1984 and research is continuing on the use of coal-water slurries, plasma burners and self-fluxed pellets which could enhance the competitive position of the Canadian industry.

## CANADIAN DEVELOPMENTS

### Quebec-Labrador

The Quebec-Labrador mines, operating at 51 per cent capacity in 1983 and 68 per cent in 1984, fared better than most other North American iron ore mines.

Although the Iron Ore Company of Canada (IOC) did not close for extented periods in 1983 or 1984, it did reduce the work force progressively to meet lower production requirements. From a total workforce of 3,710 at the end of 1982, the number of employees contracted to about 2,500 by the end of 1984. The largest number of terminations were due to closure of the Schefferville mines and cut-backs at the port of Sept-Îles in 1983.

After the closure of Schefferville, a stock of over 3 million t of direct shipping ore remained at Sept-Îles. Since then, about 1 million tpy of this product has been shipped from Sept-Îles, with the result that shipments from IOC have exceeded production for the past two years.

The addition of coke breeze in the pellet mix has allowed significant savings on energy at IOC's Carol Lake plant. Burner tests using coal-water slurry as a fuel in the pellet indurating line proceeded in 1984; further tests and plasma burner trials are planned for 1985.

The ownership of IOC changed in 1983 with the trade of Dofasco Inc.'s 16.0 per cent share of the Eveleth Mine in Minnesota for Armco Inc.'s 6.07 per cent share in IOC.

Wabush Mines closed for 50 days in 1983 and, although about 50 workers were permanently laid-off, the actual workforce was reduced by five times that number. In 1984, there was no planned shutdown and only 4 days were lost due to a strike prior to agreement on a new 3-year labour contract.

The addition of coke breeze to concentrate in the pellet plant is now a standard practice at Wabush's Pte. Noire plant, and significant energy savings are also expected from the use of coal-water

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slurry as a burner fuel, which was tested in the autumn of 1984. A major research and pilot plant proposal on the removal of manganese from the Wabush concentrate was prepared in 1984. The process, if brought to commercial scale, would remove a limiting factor in marketing Wabush iron ore and provide a valuable manganese byproduct.

Quebec Cartier Mining Company (QCM) was closed for 72 days in the summer of 1983 and its unionized employees were laid off temporarily for the last 2 months of the year. In 1984, the summer shutdown lasted 58 days. A new labour contract was signed in June, which differed from the agreement at the IOC and Wabush mines in that the cost of living allowance was replaced by a productivity bonus.

The closure of the Sidbec-Normines mine at Fire Lake and the concentrator at Gagnon, Quebec followed major financial losses to its owners since production began in 1977. The mine was closed for 80 days in 1983 and 70 days in 1984, while the pellet plant was operated at little more than one-half capacity for the 2 years. At the time of the announcement of the permanent closure, there were 610 company employees at Gagnon and Fire Lake, but with some early retirements and a transfer of some workers to QCM's Mt. Wright mine where an increase in production levels is planned, about 300 permanent lay-offs are expected to result. QCM has agreed to operate the Sidbec-Normines pellet plant at Port Cartier under a lease arrangement. The 295 pellet plant workers will transfer to QCM but the 35 office staff at Port Cartier will be laid off.

### Ontario

The four Ontario mines, considered as a group, operated at 60 per cent capacity in both 1983 and 1984.

The Adams and Sherman Mines, ownedby Dofasco Inc., closed for 3 months in 1983 and 5 weeks in 1984. The Algoma Steel Corporation, Limited's mine at Wawa, Ontario was closed for one month in 1983 and five weeks in 1984.

The closure of the Griffith mine and pellet plant, scheduled for April 1986, will affect about 280 employees in the Red Lake area. Shipments from the mine will be replaced mainly by increased purchases from the Quebec-Labrador mines.

Small shipments from Inco Limited's stockpile of iron ore pellets at Copper Cliff continued in 1983 and 1984.

### British Columbia

On October 5, 1983, Falconbridge Limited permanently closed the Wesfrob mine located at Tasu, Queen Charlotte Islands, due to depletion of economic reserves. The planned closure, which was announced in April 1983, resulted in 135 employees being laid off. All employees were given the opportunity to move at company expense. Shipments from stockpiles continued into 1984.

### Other Developments

Although 1984 exports of Canadian iron ore recovered significantly from the depressed shipments of 1982 and 1983, they did not reach the levels achieved during the 1970s.

Dofasco tested self-fluxing pellets, which were produced by Sidbec-Normines, in its Hamilton, Ontario blast furnaces in 1984 and planned to do further tests in the future. These pellets are low in silica and have dolomite added. Self-fluxed pellets could be supplied by the Port Cartier, Quebec plant, which will be operated by QCM, if the test results demonstrate that the use of these pellets would be cost-effective.

Borealis Exploration Limited continued work on its magnetite ore property on Melville Peninsula in the Northwest Territories. During 1983, a campsite was established, and a road and an airstrip were built. Work done at the Ontario Research Foundation indicated that a superconcentrate of over 71 per cent iron could be achieved using wet magnetic separation without flotation. The company reported that it is continuing discussions with several resource developers.

On December 9, 1983 the Federal Minister of Finance announced that the special tax remission for housing and travel benefits received by employees working in northern Canada and isolated posts will be continued. This extension applies to employees covered by benefit plans that were arranged before November 13, 1981. The Minister in making the annoucement, said "The northern economy and, in particular, the mining industry continue to be in a weak state due to the slow recovery of world markets and mineral prices. This tax relief will provide an impetus to recovery and allow additional time for adjustment".

## WORLD DEVELOPMENTS

Hamersley Holdings Limited of Australia announced in mid-1984 an agreement with the China Metallurgical Import and Export Corporation (CME's) to conduct a feasibility study for a joint venture iron ore mine in the Channar Mining area located about 20 km east of Hamersley's Paraburdoo operation. The announcement stated that the project would commence at a production of 5 million tpy and expand to 10 million tpy as demand warranted.

The Brazilian company, Cia Vale do Rio Doce (CVRD) plans to begin shipping ore from the Carajas Iron Ore Project in February 1985. Over 1 million t of iron ore, and 150 000 t of concentrate grading 40 per cent manganese are scheduled to be shipped during the year. The 890 km railroad linking the mine with new port facilities in Sao Luis should be completed in February 1985. Development of the mine is planned to proceed in stages so that full production at 35 million tpy can be attained in 1988.

In mid-1984, the Periquito mine at Itabira, Brazil began operations at 3 million tpy. Its rate of production was planned to increase in 1985 to 7 million tpy. The Timbopeba operation, also in Brazil, began production in April 1984 and was scheduled to produce 7.5 million tpy beginning in 1985.

Exports from Brazil were estimated at a record 90 million t in 1984, an increase of 30 per cent over its exports in 1983. This performance put Brazil in the lead as the world's largest exporter of iron ore, ahead of Australia.

Exports of iron ore from India recovered in 1984 to about 24 million t after a 15 per cent drop in 1983. The 3 million tpy pellet plant at the Kudremukh Iron Ore Co. Ltd. mine is due to be commissioned in mid-1985. The plant, part of a 7.5 million tpy iron ore complex, contributes to an Indian objective to increase exports of low-cost iron ore products.

In the United States, several permanent mine closures have resulted from the depressed iron ore market. Inland Steel Co. permanently closed the Black River Falls mine in Wisconsin almost two years after operations were halted in April 1982. The Hanna Mining Company announced that the Whitney mine, Minnesota would close permanently August 10, 1984; the mine had been inactive since 1977. CF&I Steel Corp.'s Sunrise mine, Wyoming, shut down since July 1980, was closed permanently in mid-1984 when the mine and plant equipment were auctioned. The United States Steel Corporation's mines near Cedar City, Utah were permanently closed in 1983.

In addition, several closures for indefinite periods have been in effect for many months and, in some cases, years. By mid-1984, however, the number of operating mines had recovered from the low point in 1982 and there was hope that future permanent closures could be offset by reopenings or recoveries at other mines.

A merger of Republic Steel Corp. and LTV Corp. combined the holdings of Republic and Jones & Laughlin Steel Corporation in the United States and Canadian iron mining ventures. The merged corporation will hold 50 per cent of Reserve Mining Co., 35 per cent of Erie Mining Co. and 16 per cent of Hibbing Taconite Co., in Minnesota; 35 per cent of the Empire Iron Mining partnership and 12 per cent of the Empire Tilden Mining Co., in Michigan; 15.6 per cent of Wabush Mines and 12.6 per cent of Iron Ore Company of Canada, in the Labrador Trough area.

## DIRECT REDUCTION AND PLASMA TECHNOLOGY

Ivaco Inc., at L'Orignal, Ontario had planned to install an Inred hot metal direct reduction DR plant based on Boliden Aktiebolog technology. However, the availability of steel billets in the near future from QIT-Fer et Titane Inc. of Sorel, Quebec, eliminated the need for the DR plant.

Sidbec-Dosco Inc. at Contrecoeur, Quebec produced somewhat less direct-reduced iron in 1984 than in 1983. The operation of the Midrex Corp. designed plant remained at close to one-half its 1.2 million tpy capacity.

Midrex Corp. received and order to conduct a $250,000 feasibility study on converting one of Sidbec-Dosco Inc.'s natural gas-based Midrex direct reduction plants to electric reforming. The study will evaluate the possibility of partially replacing natural gas reforming with either plasma electric reforming or resistance electric reforming. Sidbec expects that operating costs should be substantially reduced by replacing some of the natural gas fuel with hydro-electric power. A coal-based plasma reforming alternative for completely replacing natural gas will also be considered in the study.

## PRICES

The Lake Erie base price for Mesabi non-Bessemer ore recovered to the 1981 level in 1983 but dropped back in 1984. Pelletprices increased very little in 1983 and remained at that level in 1984.

World prices for iron ore, especially pellets, came under heavy pressure in 1983 and 1984, and prices declined in both years. The gap between the pellet and fines prices decreased from between 15 and 20 cents an iron unit to about 10 cents a unit. At the same time, the gap between the Lake Eric price for pellets and the price in Europe and Japan increased from about 30 cents a unit in 1981 to 40 cents a unit in 1984. With the Lake Eric price double the world price for pellets, steel companies in North America were considering alternative ways to reduce the cost of their ore requirements.

## OUTLOOK

World iron ore production capacity is currently estimated at 1 800 million t. Meanwhile, production was only 774 million t in 1983, indicating capacity utilization of about 43 per cent. The growth rate for steel production in the medium-term has been forecast at 1.5 per cent and, with more use of continuous casting and higher levels of scrap recovery, iron ore consumption is likely to grow at an even slower rate. Therefore, world production capacity is projected to exceed iron ore consumption for the rest of this century.

In spite of the chronic oversupply situation, some 75 million t of annual production capacity is under construction. Brazil alone accounts for about 50 million t, and eight other countries account for the remainder.

The financial arrangement for the Carajas project in Brazil required almost $US 1.5 billion foreign debt and $US 1.2 billion domestic borrowing, which together could place a severe burden, in terms of interest payments, on Brazil as a whole.

On the other hand, operating costs at the Carajas project are relatively low because of the high-grade of ore, requiring little benefication, the ease of mining with relatively little blasting necessary, and labour costs which are a fraction of North American and European wages, in U.S. dollar terms. These two factors, high debt load and low operating costs create a situation where the highest return on investment will likely result from operation and sale at the limit of production capacity, even if the price is well below the established international level. Because of this, many analysts expect downward pressure on price to be maintained well into the 1990s as the expansions in Brazil carve out a share of the international iron ore market.

In Australia, mining costs are relatively low because of the large scale of the open pit mines and the high grade ore (average above 60 per cent iron). In the interests of maximizing profit, rather than total foreign earnings, the Australian producers will likely concentrate their efforts on market share and price, through the pursuit of opportunities for long-term contracts and joint venture development with consumers.

India also has low operating costs at a number of mines that were developed for the foreign market. The National Mineral Development Corporation was in the process of merging with the Minerals and Metals Trading Corporation (MMTC), which will create a near monopoly for the export of Indian iron ore. As a result, the aggressive marketing of iron ore, long established by Indian exporters, will likely be fused with demands for higher prices in future negotiations.

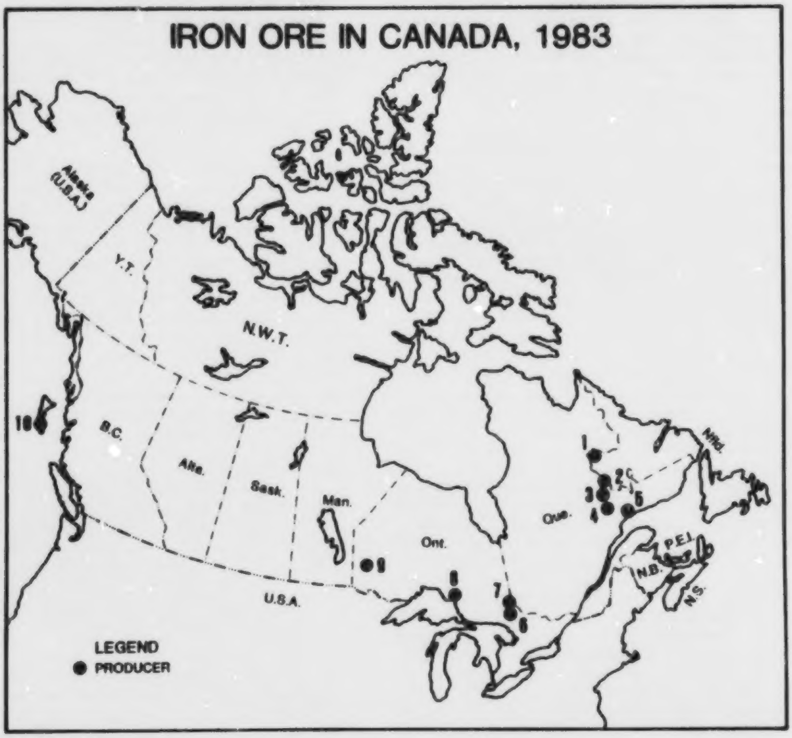
The Swedish iron ore producers, largely dependent on underground mining, face higher than average operating costs. The publicly stated policy of the Swedish exporters is to maintain a stable level of exports and to concentrate on gaining a premium price by producing high quality products, such as self-fluxing olivine pellets.

Other major iron ore exporters, such as Liberia, Mauritania, Chile, Peru, South Africa and Venezuela are expected to favour volume of exports and market share as priorities, and to place less importance on higher prices.

For Canadian exporters of iron ore, the medium-term will remain difficult. The grade of ore at operating mines ranges from 18 to 39 per cent iron, and all of the ore must be concentrated before shipping. Accordingly, Canadian operating costs are higher than in Brazil and Australia, and depressed ocean freight rates are likely to continue to reduce the shipping advantage normally enjoyed by Canadian suppliers.

The performance at Canadian mines, therefore, will be very dependent on price negotiations. Canadian concentrates and pellets are recognized as having high quality and reliable standards, but this has had little effect on price in the past. However, the potential to improve quality and offer premium iron ore products, as practised in Sweden, could be exploited further in Canada because of the sound technological base already in place. Rationalization to reduce costs, initiatives to preserve market share in the key markets, and capitalizing on short-term imbalances in the more distant markets appears to be the most likely strategy of Canadian iron ore exporters, and one that could produce a reasonable return over the long-term.

Within the North American market, steel producers have increased their iron ore consumption from the low levels of 1982 and 1983. A further increase in consumption is expected in 1985, but growth thereafter will likely be very slow. For Canadian and United States iron ore mines, there will likely be some loss of market to imports from Brazil, and the price will remain under pressure because of the large surplus production capacity and low prices outside North America.



IRON ORE IN CANADA, 1983

Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
1
2
2
3
4
5
5
6
7
8
9
10
LEGEND
● PRODUCER

**Producers**
(numbers refer to numbers on map above)

1. Iron Ore Company of Canada, Knob Lake Division (Schefferville)
2. Iron Ore Company of Canada, Carol Division (Labrador City)
2. Scully Mine of Wabush Mines (Wabush)
3. Quebec Cartier Mining Company (Mount Wright)
4. Sidbec-Normines Inc. (Gagnon, Fire Lake)
5. Iron Ore Company of Canada, Sept-Iles Division (Sept-Iles)
5. Wabush Mines, Pointe Noire Division (Pointe Noire)
5. Quebec Cartier Mining Company and Sidbec-Normines Inc. (Port Cartier)
6. Sherman Mine of Dofasco Inc. (Temagami)
7. Adams Mine of Dofasco Inc. (Kirkland Lake)
8. Algoma Ore division of The Algoma Steel Corporation, Limited (Wawa)
9. The Griffith Mine (Bruce Lake)
10. Wesfrob Mines Limited (Moresby Is.)

## TABLE 1. CANADA, IRON ORE PRODUCTION AND TRADE, 1982-84

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes)[1] | ($000) | (tonnes)[1] | ($000) | (tonnes)[1] | ($000) |
| **Production** (mine shipments) | | | | | | |
| Newfoundland | 15 886 000 | 572,386 | 18 404 585 | 711,727 | 21 669 849 | 867,622 |
| Quebec | 12 984 000 | 428,335 | 10 246 761 | 372,880 | 14 745 000 | 362,448 |
| Ontario | 3 633 000 | 180,905 | 3 810 509 | 172,239 | 4 478 480 | 235,065 |
| British Columbia | 602 000 | 14,307 | 496 823 | 13,078 | 172 000 | 5,775 |
| Total[2] | 33 198 000 | 1,201,256 | 32 958 678 | 1,269,924 | 41 065 329 | 1,470,910 |
| **Imports** | | | | | (Jan.-Sept. 1984) | |
| Iron ore | | | | | | |
| United States | 3 359 303 | 192,294 | 3 977 869 | 231,976 | 3 377 629 | 201,732 |
| Brazil | - | - | 35 232 | 1,267 | 104 607 | 2,915 |
| Netherlands | - | - | 2 | 2 | - | - |
| Italy | - | - | 6 | 1 | 14 | 1 |
| Total | 3 359 303 | 192,294 | 4 013 109 | 233,246 | 3 482 250 | 204,648 |
| **Exports** | | | | | | |
| Iron ore, direct shipping | | | | | | |
| United States | 1 231 718 | 28,380 | 824 886 | 17,589 | 1 124 958 | 22,200 |
| Italy | 373 614 | 7,411 | 344 469 | 6,364 | 168 175 | 3,168 |
| Belgium and Luxembourg | 87 462 | 2,186 | 61 778 | 1,236 | 69 007 | 1,252 |
| United Kingdom | - | - | 57 030 | 1,084 | 53 671 | 1,020 |
| Total | 1 692 794 | 37,977 | 1 288 163 | 26,273 | 1 415 811 | 27,640 |
| Iron ore, concentrates | | | | | | |
| Japan | 2 871 436 | 69,286 | 2 986 123 | 70,089 | 2 350 891 | 50,071 |
| West Germany | 1 818 107 | 44,463 | 2 015 388 | 53,069 | 1 601 726 | 36,491 |
| United Kingdom | 2 022 900 | 50,488 | 1 757 046 | 41,289 | 791 509 | 17,255 |
| Netherlands | 3 440 354 | 83,292 | 1 255 670 | 30,556 | 2 335 860 | 52,942 |
| United States | 1 772 368 | 64,579 | 1 188 091 | 28,538 | 1 350 572 | 31,167 |
| France | 1 058 685 | 28,771 | 925 331 | 22,898 | 783 747 | 15,954 |
| Yugoslavia | 127 243 | 3,489 | 319 995 | 10,842 | 408 558 | 13,786 |
| Italy | 812 854 | 19,825 | 442 408 | 10,516 | 241 558 | 5,162 |
| Philippines | 288 926 | 7,223 | 307 588 | 7,222 | 208 081 | 4,525 |
| Austria | 105 465 | 2,795 | 213 388 | 6,035 | 87 691 | 1,697 |
| Belgium and Luxembourg | 424 342 | 11,567 | 203 893 | 4,893 | 154 349 | 3,536 |
| Portugal | 49 365 | 1,721 | 110 036 | 2,723 | 90 399 | 2,512 |
| Pakistan | 125 707 | 3,007 | 99 745 | 2,192 | 131 508 | 2,870 |
| Spain | 252 822 | 7,046 | 61 471 | 1,977 | - | - |
| Other countries | 50 132 | 1,749 | 51 936 | 1,429 | 234 442 | 5,892 |
| Total | 15 220 706 | 399,301 | 11 938 109 | 294,268 | 10 770 891 | 243,858 |
| Iron ore, agglomerated | | | | | | |
| United States | 5 950 756 | 335,958 | 6 852 094 | 376,612 | 6 839 108 | 395,168 |
| United Kingdom | 1 771 653 | 109,957 | 3 040 908 | 180,045 | 1 847 642 | 79,962 |
| Netherlands | 1 010 763 | 61,600 | 606 964 | 31,602 | 533 103 | 22,672 |
| Italy | 348 246 | 16,489 | 470 470 | 22,458 | 477 257 | 22,633 |
| West Germany | 819 771 | 47,749 | 144 648 | 8,704 | 662 837 | 26,327 |
| France | - | - | 141 274 | 3,851 | - | - |
| Japan | 81 390 | 4,965 | 148 645 | 3,383 | - | - |
| Other countries | 305 146 | 16,736 | 147 577 | 6,004 | 158 349 | 6,396 |
| Total | 10 287 725 | 593,454 | 11 552 580 | 632,659 | 10 518 296 | 553,158 |

TABLE 1. (cont'd.)

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes)[1] | ($000) | (tonnes)[1] | ($000) | (tonnes)[1] | ($000) |
| Iron ore, nes | | | | | | |
| Netherlands | - | - | 304 853 | 7,148 | - | - |
| United Kingdom | - | - | 186 253 | 4,191 | - | - |
| Yugoslavia | - | - | 99 999 | 5,387 | - | - |
| United States | 80 147 | 2,801 | 59 080 | 1,596 | 25 729 | 708 |
| Other countries | 23 | 1 | 98 923 | 2,442 | - | - |
| Total | 80 170 | 2,802 | 749 108 | 18,764 | 25 729 | 708 |
| Total exports, all classes | | | | | | |
| United States | 9 034 989 | 431,718 | 8 924 151 | 424,335 | 9 340 367 | 449,243 |
| United Kingdom | 3 794 553 | 160,445 | 5 041 237 | 226,609 | 2 692 822 | 98,237 |
| Netherlands | 4 451 117 | 144,892 | 2 167 487 | 69,306 | 2 868 963 | 75,614 |
| West Germany | 2 637 878 | 92,212 | 2 160 036 | 61,773 | 2 264 563 | 62,818 |
| Japan | 2 952 826 | 69,286 | 3 134 768 | 73,472 | 2 350 891 | 50,071 |
| Italy | 1 534 714 | 43,725 | 1 257 347 | 39,338 | 886 990 | 30,963 |
| Belgium and Luxembourg | 511 804 | 28,871 | 265 671 | 6,129 | 256 796 | 6,895 |
| France | 1 058 685 | 28,771 | 1 066 685 | 26,749 | 783 747 | 15,954 |
| Philippines | 288 926 | 7,223 | 307 588 | 7,222 | 208 081 | 4,525 |
| Yugoslavia | 127 243 | 3,489 | 419 994 | 14,229 | 408 558 | 13,786 |
| Other countries | 888 660 | 22,902 | 783 076 | 22,802 | 668 949 | 17,260 |
| Total | 27 281 395 | 1,033,534 | 25 528 070 | 971,964 | 22 730 727 | 825,364 |
| Consumption of iron ore at Canadian iron and steel plants | 11 999 449 | .. | 13 102 908 | .. | 14 620 016 | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada; American Iron Ore Association.
[1] Dry tonnes for production (shipments) by province; wet tonnes for imports and exports. [2] Total iron ore shipments include shipments of byproduct iron ore.
P Preliminary; - Nil; .. Not available; nes Not elsewhere specified.

## TABLE 2. CANADA, IRON ORE PRODUCTION (SHIPMENTS), 1981-84

| Company and Location | Ore Mined | Product Shipped | 1981 | 1982 | 1983 | 1984P |
|---|---|---|---|---|---|---|
| Adams Mine, Kirkland Lake, Ont. | Magnetite | Pellets | 1 231 | 964 | 865 | 1 134 |
| Algoma Ore division of The Algoma Steel Corp. Ltd., Wawa, Ont. | Siderite | Sinter | 1 485 | 871 | 1 247 | 1 250 |
| Caland Ore Company, Limited Atikokan, Ont. | Hematite and goethite | Pellets | - | - | - | - |
|  |  | Concentrate | 142 | - | - | - |
| Griffith Mine, Bruce Lake, Ont. | Magnetite | Pellets | 1 538 | 910 | 790 | 970 |
| Iron Ore Company of Canada Schefferville, Que. | Hematite, goethite and limonite | Direct shipping | 2 833 | 1 675 | 1 366 | 1 527 |
| Carol Lake, Lab. | Specular hematite and magnetite | Concentrate | 7 091 | 5 609 | 5 618 | 5 751 |
|  |  | Pellets | 10 057 | 5 830 | 6 590 | 8 190 |
| Sept Iles, Que. | Schefferville "treat ore" | Pellets | 1 348 | 129[1] | 235 | 157 |
| Quebec Cartier Mining Company, Mount Wright, Que. | Specular hematite | Concentrate | 13 139 | 9 048 | 6 683 | 9 637 |
| Sidbec-Normines Inc. Fire Lake and Lac Jeannine, and Port Cartier, Que. | Specular hematite | Concentrate | 50 | 47 | - | - |
|  |  | Pellets (standard) | 3 500 | 3 122 | 3 211 | 4 951 |
|  |  | Pellets (low silica)[2] | 1 344 | 681 | 495 | - |
| Sherman Mine, Temagami, Ont. | Magnetite | Pellets | 1 142 | 850 | 760 | 1 124 |
| Wabush Mines, Wabush, Labrador and Pointe Noire, Que. | Specular hematite and magnetite | Pellets | 5 291 | 3 048 | 5 180 | 6 202 |
| Wesfrob Mines Limited, Queen Charlotte Islands, B.C. | Magnetite | Pellet feed | 537 | 726 | 492 | 172 |
|  |  | Fine magnetite | 39 | 37 | - | - |
| Byproduct producer |  |  |  |  |  |  |
| nco Limited, Sudbury, Ont. | Pyrrhotite | Pellets | 54 | - | - | - |
|  |  | Magnetite concentrate | 126 | - | - | - |
| Total |  |  | 50 947 | 33 547 | 33 532 | 41 065 |

Stockpile ore. [2] Included with standard pellets in 1984.
Nil; P Preliminary.

### TABLE 3. RECEIPTS AND CONSUMPTION OF IRON ORE AT CANADIAN IRON AND STEEL PLANTS, AND INVENTORIES, 1983 AND 1984

| | 1983 | 1984$^e$ |
|---|---|---|
| | (tonnes) | |
| Receipts imported | 4 230 377 | 5 231 331 |
| Receipts from domestic sources | 8 558 519 | 10 476 690 |
| Total receipts at iron and steel plants | 12 788 890 | 15 708 021 |
| Consumption of iron ore | 13 102 894 | 14 620 691 |
| Inventory at docks, plants, mines and furnace yards, December 31 | 12 491 962 | 10 123 416 |
| Inventory change | -4 341 623 | -2 368 546 |

Source: American Iron Ore Association.
$^e$ - based on 11 month data.

### TABLE 4. WORLD IRON ORE PRODUCTION, 1981-83

| | 1981 | 1982 | 1983$^e$ |
|---|---|---|---|
| | (000 tonnes) | | |
| U.S.S.R. | 242 023 | 243 953 | 244 868 |
| Brazil | 99 979 | 110 038 | 99 573 |
| Australia | 85 958 | 87 787 | 83 316 |
| People's Republic of China$^e$ | 70 107 | 70 006 | 71 123 |
| India | 41 150 | 40 947 | 40 642 |
| United States | 74 375 | 35 968 | 38 610 |
| Canada (mine shipments) | 49 551 | 33 549 | 33 532 |
| Republic of South Africa | 28 348 | 24 588 | 22 353 |
| France | 21 642 | 19 407 | 18 289 |
| Liberia | 19 711 | 18 187 | 15 241 |
| Sweden | 23 267 | 16 155 | 14 225 |
| Venezuela | 15 546 | 11 685 | 10 160 |
| Other countries | 88 092 | 82 706 | 79 252 |
| Total | 859 749 | 794 625 | 770 034 |

Sources: U.S. Bureau of Mines Mineral Commodity Summaries, 1983, 1984; Energy, Mines and Resources Canada.
$^e$ Estimated.

### TABLE 5. CANADIAN CONSUMPTION OF IRON-BEARING MATERIALS BY INTEGRATED[1] IRON AND STEEL PRODUCERS, 1983

| | Consumed In | | | | |
|---|---|---|---|---|---|
| | | | Iron and Steel Furnaces | | |
| Material Consumed | Sinter Plants at Steel Mill | Direct Reduction Plants | Production of Pig Iron | Steel Furnaces | Total in Furnaces |
| | | | (tonnes) | | |
| Iron Ore | | | | | |
| Crude and concentrate | 40 882 | 112 037 | 42 238 | | 42 238 |
| Pellets | 6 455 | 687 465 | 10 901 151 | 56 588 | 10 957 738 |
| Sinter | 16 243 | - | 1 226 546 | - | 1 226 546 |
| Sinter produced at steel plant | - | - | 169 714 | - | 169 714 |
| Direct reduced iron | - | - | - | 516 097 | 516 097 |
| Other iron-bearing materials | | | | | |
| Flue dust | 9 947 | - | - | - | - |
| Mill scale, sinder, slag | 85 691 | - | 334 398 | 4 112 | 338 511 |
| Total | | | | | 13 250 844 |

Source: Company data.
[1] Dofasco Inc.; Sidbec-Dosco Inc.; Sydney Steel Corporation; The Algoma Steel Corporation, Limited; Stelco Inc.
- Nil

### TABLE 6. LAKE ERIE BASE PRICE OF SELECTED ORES AT YEAR-END, 1970, 1975 AND 1980-84

| | 1970 | 1975 | 1980 | 1981 | 1982 | 1983 | 1984 |
|---|---|---|---|---|---|---|---|
| | | | | ($US) | | | |
| Mesabi Non-Bessemer[1] | 10.63 | 18.21 | 28.05 | 32.02 | 31.73-32.01 | 32.25-32.53 | 30.03-31.53 |
| Old Range Non-Bessemer[1] | 10.87 | 18.45 | 28.30 | 32.26 | 32.26 | 32.78 | 32.78 |
| Pellets (per natural iron unit)[2] | 0.262 | 0.464 | 0.725 | 0.792 | 0.792-0.855 | 0.805-0.869 | 0.805-0.869 |
| Direct Reduced Pellets[3] | | | | | | 115-135 | 115-135 |

Sources: Skillings Mining Review; Iron Age.

[1] $US per gross ton, 51.5 per cent of iron natural, at rail of vessel, lower lake ports. [2] $US per gross ton natural iron unit. One iron unit equals 1 per cent of a ton; an ore containing 60 per cent iron, therefore, has 60 iron units. [3] $US per metric tonne.

### TABLE 7. SELECTED PRICES OF IRON ORE BOUND FOR JAPAN AND EUROPE 1979-84

(U.S. cents per Fe Unit DMT, FOB)

| Ore | Market | Source | %Fe | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 |
|---|---|---|---|---|---|---|---|---|---|
| Fines (including concentrate) | Europe | Rio Doce | (64) | 23.5 | 28.1 | 28.1 | 32.5 | 29.0 | 26.15 |
| | | Iscor | (65) | 22.4 | 26.9 | 26.9 | 31.4 | 27.9 | 20.60 |
| | | Kiruna | (66) | 26.6 | 34.5 | 33.0 | 34.7 | 30.1 | 27.7 |
| | | Carol Lake | | 23.7 | 29.3 | 29.3 | 33.0 | 29.3 | 26.8 |
| | | Mt. Wright | (66) | 24.0 | 29.75 | 29.75 | 33.0 | 29.3 | 26.8 |
| | Japan | Rio Doce | | 21.6 | 25.4 | 26.9 | 30.5 | 27.5 | 24.3 |
| | | Iscor | | 21.6 | 25.0 | 26.9 | 30.5 | 27.0 | 23.9 |
| | | Hamersley | | 22.7 | 27.6 | 29.7 | 34.2 | 30.5 | 26.7 |
| | | Carol Lake | (65) | 21.4 | 25.1 | 27.0 | 29.8 | 26.7 | 23.4 |
| Lump | Europe | Rio Doce | | 26.6 | 31.2 | 31.2 | - | - | - |
| | | Iscor | (65) | 25.5 | 31.9 | 31.9 | 35.9 | 31.3 | 24.0 |
| | Japan | Rio Doce | | 21.6 | 25.4 | 26.9 | 30.5 | 27.9 | 24.6 |
| | | Iscor | (65) | 24.7 | 28.6 | 30.9 | 35.0 | 30.6 | 27.2 |
| | | Hamersley | | 25.7 | 31.2 | 34.2 | 40.0 | 34.9 | 30.9 |
| Pellets | Europe | Rio Doce | | 40.2 | 47.1 | 43.1 | 47.5 | 39.0 | 36.0 |
| | | Kiruna | | 42.2 | 49.9 | 48.5 | 50.2 | 41.0 | 38.6 |
| | Japan | Rio Doce (Nibrasco) | | 46.0 | 50.3 | 55.2 | 53.6 | 42.9 | 37.3 |
| | | Savage River | | 37.9 | 46.2 | 48.9 | 53.4 | - | 38.3 |

Sources: The Tex Report, Metal Bulletin and Japan Commerce Daily.
- Not available; DMT dry metric tonne; FOB free on board.

## TABLE 8. CAPACITY AND PRODUCTION OF DIRECT REDUCED IRON (DRI), 1983

| Country | Capacity (million tpy) | Production (million t) |
|---|---|---|
| Argentina | .930 | .949 |
| Brazil | .315 | .255 |
| Burma | .020 | .010[e] |
| Canada | 1.625 | .538 |
| India | .180 | .042 |
| Indonesia | 2.300 | .500[e] |
| Iran | .330 | .000 |
| Iraq | .485 | .000 |
| Mexico | 2.025 | 1.498 |
| New Zealand | .150 | .155 |
| Nigeria | 1.020 | .162 |
| Peru | .100 | .026 |
| Quatar | .400 | .383 |
| Saudi Arabia | .800 | .351 |
| South Africa | .225 | .076 |
| Sweden | .070 | .020[e] |
| Trinidad | .840 | .283 |
| U.S.S.R. | .417 | .015[e] |
| United States | 1.090 | .000 |
| Venezuela | 4.452 | 2.468 |
| West Germany | 1.280 | .070[e] |
|  | 19.054 | 7.801 |

Source: Midrex Corp., North Carolina, United States.

[e] Estimated.

# Iron and Steel

R. McINNIS

## SUMMARY

Nineteen eighty three marked the beginning in North America of a consumer-led recovery that gained momentum throughout the year and continued in 1984. Capital expenditure began to increase by mid-1984. In other parts of the western world the recovery began later than in North America, and was much weaker in some regions such as western Europe.

International trade was characterized by national efforts to gain protection from imported steel. Investigations into steel trade resulted in a variety of restrictions to trade such as quotas and anti-dumping duties, especially in North America.

Operating rates of Canadian mills increased from 45 per cent at the beginning of January 1983 to 69 per cent at the end of December 1983. The industry reached 75 per cent of its production capacity in March 1984. However, the average rate of capacity utilization was 68 per cent in 1984.

Canadian crude steel production in 1983 increased 7.2 per cent to 12.1 million t, and increased a further 14.2 per cent in 1984 to 14.5 million t.

Rolled steel shipments from dometic mills, including ingot and semis, increased by 6.9 per cent in 1983 to 10.0 million t, with a further increase of 18.7 per cent to an estimated 11.8 million t in 1984.

Canadian trade figures also reflected the upturn in the global economy. Exports increased by 13.0 per cent to 3.2 million t in 1983 and 12.1 per cent to 3.6 million t in 1984. Imports increased even faster at 60 and 47 per cent in the last two years to 1.5 and 2.2 (estimate) million t respectively.

Employment levels decreased from an average of 49,470 in 1982 to 46,666 in 1983, but rebounded to 49,868 in September 1984. Employment statistics before April 1983 are not fully comparable with later statistics because of changes in Statistics Canada survey methods.

A world oversupply of steel will persist in the medium-term in spite of planned plant closures. The installation of modern equipment based on new cost-saving technologies at existing plants will increase productivity in developed nations. The developing nations will continue to add to their capacity, increasing world output while growth in steel consumption will be modest.

## CANADIAN DEVELOPMENTS

Capital expenditures in the Canadian steel industry totalled $198 million in 1983, a considerable drop from the $416 million of 1982 which was also lower than previous years. The demand for steel strengthened in 1984 and capital expenditure intentions improved to $ 226.5 million. Many new projects have been announced and capital expenditures should continue to increase in 1985.

Although the consumption of steel increased throughout 1983, total production was only slightly better than in 1982. The recovery gathered strength during 1984 as demand for consumer durables, especially automobiles, increased significantly. Highlights by company are as follows:

**Stelco Inc.** The 80-inch hot strip mill at Stelco's Lake Erie Works began operating in May 1983. This mill completes the first phase of this new integrated works.

The company completed a reline of D blast furnace at Hilton Works, with start-up coinciding with the shutdown of F furnace for relining. The #1 bloom and billet mill was permanently closed. Increased quality and productivity were highlighted in 1983 capital expenditures. Improvements were made on the process for desulphurization of the hot metal fed to the Basic Oxygen Furnace (BOF), a microprocess control system was installed on the 5-strand cold reduction mill, and Lance Bubbling

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Equilibrium Process (LBE) was installed on a second (#5) BOF. In October 1984, the company announced a major 5-year upgrading program that will cost approximately $400 million at the Hilton Works. This will involve improvements to the basic oxygen steelmaking facilities, installation of a continuous slab caster and a continuous slab/bloom caster, and the modernization of the company's #1 bar mill. Completion is scheduled for 1987.

Lake Erie, Montreal, and Edmonton Works operated at capacity while the older Hilton Works operated at somewhat less than 50 per cent of capacity in 1983 and at 50 per cent in 1984, an improvement over the 40 per cent rate of 1982. Increasing sales of steel and a rundown of inventories were deciding factors in the company's decision to recall 1,500 employees. The Edmonton Steel Works operated at capacity because low scrap prices and reduced freight rates made it economical to ship cast billets to Hamilton.

An internal reorganization in 1983 grouped several existing branches into an autonomous business unit called Stelco Fastner and Forging Company, with responsibilities for manufacturing and marketing fastners and forgings. Effective November 1, 1984, Stelco Pipe and Tube Co. was organized as another profit centre and made responsible for the manufacturing and marketing of pipe and tubular products.

**Dofasco Inc.** Increasing orders for steel, particularly for flat products, enabled Dofasco to recall by the third quarter of 1983 all 2,100 employees that had been laid off in 1982.

Capital expenditures in 1983 were slightly more than $52 million, most of which was required for the completion of the company's $91 million No. 2 hot strip rolling mill. Expenditures for 1984 were concentrated on the #4 continuous pickle line, which was completed in March 1984, and on the conversion of the #1 galvanizing line to the production of Galvalume. In November 1984, the company announced a $600 million expansion and modernization program that will include the installation of continuous casting equipment. The program is scheduled for completion in 1987.

The company's specilization in the production of high-value sheet steel products that are used in the production of automobiles and other consumer durables was largely responsible for profitability in both 1983 and 1984. Shipments in 1983 were 6.6 per cent higher than in 1982 and up 22.5 per cent in the first nine months of 1984 compared to the same period in 1983.

**The Algoma Steel Corporation, Limited.** Algoma continued to delay construction of its new seamless tube mill, although the delivery of machinery continued throughout much of 1983. A 72-year old merchant mill was closed on October 28 and a grinding ball mill on September 17, 1983. Both of these non-competitive mills are located at Sault Ste. Marie. The production of merchant pig iron was discontinued.

Capital expenditures were reduced to $32 million in 1983 compared to $ 184.5 million in 1982. Capital expenditures in 1984 were to be limited to $50 million and used for improvements in the quality of continuous cast billets, for improvements in steelmaking and for a product rationalization program. Future capital expenditures will stress cost competitiveness and product quality rather than higher production capacities.

The company's specialization in heavy structurals, plate and line pipe used in capital equipment construction and the oil industry contributed to the difficulties and losses the company faced in 1983 and 1984. A revival of capital investment, especially for new tar sands projects and the twinning of railway lines, should improve the demand for Algoma's products in 1985.

**IPSCO Inc.** Low demand for tubular products was responsible for reduced operating rates in 1983 and resulted in temporary employee layoffs . Sales improved in fiscal 1984 to $280 million from $193 million in 1983, and earnings doubled to $14.6 million, a level still far below average earnings in 1980-82. The increased oil and gas drilling activity in Canada and the overall improvement in the North American economy were important factors in improved markets. Company sales were also improved by the broader product mix and the higher percentage of flat rolled products now produced.

IPSCO was actively engaged in the purchase, sale and expansion of business interests. The sale of Wescan Pipe Protectors Ltd., a 51 per cent owned subsiduary, was announced in September 1983. An offer to purchase $17.7 million for the assets of a bankrupt pipe company, Steel Corp. Ltd. of Red Dear, Alberta was in November.

Higher quality and productivity improvements have been the goals of recent capital expenditures. A $ 10 million expansion of the company's Regina Steel Works was announced in September, 1983. Funds totalling $28.5 million were raised by a rights issue and these will be used for a modernization and expansion program that will include the installation of a continuous caster, a slab reheat furnace and related rolling mill modifications at a projected cost of $63 million. Completion is scheduled for late-1986.

IPSCO Inc. became the company's formal name on April 21, 1984 when it was changed from Interprovincial Steel and Pipe Corporation Ltd.

**Atlas Steels division of Rio Algom Limited.** Poor demand and low prices for specialty and stainless steels characterized 1983. However, improved markets for automobiles and consumer durables increased orders for some of the company's products late in the year. The company's 1983 operating loss was significantly lower than that in 1982. Atlas' products are widely used in the production of capital goods and, although the consumer-led recovery continued in 1984, there was no significant increase in capital expenditures until the last quarter of the year. Profitable operating rates were reached in 1984.

Capital expenditures were minimized in 1983-84 and efforts were directed to cost reduction, product development and quality improvement.

**Sydney Steel Corporation (Sysco).** On December 15, 1983, an explosion in Sysco's only operating blast furnace caused the death of three workers and resulted in a temporary layoff of plant workers while the furnace was being repaired.

Stage I of the company's $96.2 million modernization program was scheduled for completion by March 31, 1985. The largest component of this phase, the rebuilding and modernization of a blast furnace, was completed. The furnace was lit in September 1984 and the inital production target was attained. The company was satisfied with the quality of the iron being produced. Stage 2 of the modernization program was being planned in 1984.

The company operated seven shifts a week and employed 1,200 people during 1983. At year-end 1984, the employment level had increased to 1,475, including 140 working on construction. The operating level in 1984 varied from 7 to 9 shifts per week, depending on shipping requirements.

Sysco shipped rails to Mexico and Mozambique, in addition to domestic sales to Canadian National Railways. The elimination of the Crow rate for grain shipments and the upgrading of rail lines, including double tracking, strengthened the domestic market for rail.

**Slater Steels Corporation.** This is the new name for the corporation formerly called Slater Steel Industries Limited. The company's divisions have also been renamed to reflect its specialization in steel production. Burlington Steel became Hamilton Specialty Bar Division, Joslyn Stainless Steels became Fort Wayne Specialty Alloys Division and Crucan became Sorel Forge Division. Salcan, the division that specilizes in the manufacture of hardware for telephone and electric lines, was not renamed. Efforts have been made to sell this division as it is outside the company's main area of specilization.

Fiscal 1983 was a low point in the company's financial history, with sales 26 per cent below the level of the previous year. Sales of the company's products, including forgings from the company's recently purchased Sorel Forge Division, increased by over 25 per cent in 1984. This excellent improvement was however, not enough to return the corporation to its pre-recession levels. The company was building on its strength and skill in steelmaking and processing, with 1984 capital expenditures of $5.57 million going primarily for upgrading of equipment and processes. The corporation is well positioned to benefit from any further improvements in the economy.

Sales in the first three months of the latest fiscal year ending June 30, 1984 improved 43 per cent over the same period in the previous year.

Slater's 20.2 per cent interest in IPSCO Inc. was sold in November 1984.

**Lake Ontario Steel Company Limited (LASCO).** Plant and process modernization continued in 1983-84 and included the following: installation of a new speed control system on the rolling mill that allows both higher rolling speeds and greater uniformity of section dimensions; addition of another strand to the existing continuous casting machine; installation of oxygen fuel burners to the arc furnace to increase the energy input to the furnace, and thereby reducing melt times and improving the productivity of the furnace; development of a ladel injection practice that improves the chemistry and the quality of the steel produced.

**QIT-Fer et Titane Inc. (QIT)** announced plans to diversify into the production of high-quality steel billet, a decision which will require an investment program totalling $154 million. The company produces pig iron as a coproduct with titanium slag in its illmenite smelting facilities at Sorel, Quebec. This high purity iron will allow the company to produce steel with a relatively small capital investment. The new facilities will include continuous casting machinery for the production of billets.

Important considerations in reaching this investment decision included a severe downturn in the company's historic market for pig iron in Europe and the United States; the qualification of the project for a $25 million grant from the Quebec Government; and a risk sharing contract with Hydro Québec that guarantees a 20-year period of electric power at an attractive rate. If the new product mix proves to be profitable for QIT, part of the rebate on electricity costs will be paid back. However, if another recessionary period develops and the plant is unprofitable, Hydro Québec will maintain the special low rates.

**Ivaco Inc.** Expansion remained a priority with Ivaco and this goal was pursued by a combination of capital expenditures at existing plants and acquisitions. In November 1983, Ivaco acquired 51 per cent of the shares of Laclede Steel Company of St. Louis, Missouri. This new subsidiary added 800 000 t of steel capacity and the facilities to manufacture bar, flat bar, plate, strip, wire and continuously welded pipe.

A recent purchase of Dofasco shares has moved Ivaco to the position of the largest single shareholder of Dofasco, with 12 per cent of issued shares.

Capital investment in 1983 at $16.6 million was down relative to previous years. However, in the first 9 months of 1984, expenditures were up sharply to $29.5 million. Capital expenditures associated with steelmaking were mainly on ladel metallurgy technology for the refinement and alloying of steel outside of the electric furnace. Such facilities help to optimize the flow of metal to the continuous casting machine.

An arrangement with Boliden AB of Sweden regarding the proposal construction of an INRED smelting plant at l'Orignal, Ontario was cancelled. An agreement to purchase 225 000 tpy of high quality billets for a period of three years from QIT Fer et Titane's new plant in Quebec has reduced Ivaco's need to produce high-purity iron.

## WORLD DEVELOPMENTS

A rapid change within the steel industries of the western world occurred in 1983-84. A worldwide surplus of steel persisted even though some economies began to recover from the recession of the previous year. Strong demand for consumer durables led the recovery in North America in early 1983. However, an increase in capital spending did not begin until the last half of 1984. The recovery began later in the rest of the western world.

Steel industries in developed nations reacted to the depressed market and oversupply by closing obsolete plants and rationalizing the rest of their facilities. In the United States, steel production capacity was reduced from the 1980 peak of 146 million t to 123 million t in 1984. A further 10 million t is likely to be closed in the next few years. In the European Community (EC), the industry rationalization and plant closures had been formalized under the seven year old d'Avignon plan wherein member countries agreed to stop subsidizing their steelmakers and to reduce capacity by 26.7 million t to 141.9 million t by 1985.

The rationalization that occurred in the developed nations has reduced the cost of producing steel, partially by a reduction of manning rates but also by investment in new steelmaking technologies such as continuous casting. Many companies have specialized in higher-quality, higher-value-added products, and more capital investment will be made in the near future. For many companies the breakeven point has been lowered considerably so they can now operate profitably at much lower levels of capacity utilization.

Developing nations have responded to the oversupply of steel by reducing their rate of investment. Many planned steelmaking complexes have been put on hold.

In summary, the western world's steel capacity was approximately 600 million t at year end 1984, still considerably higher than consumption of about 440 million t for 1984. This latter level of consumption follows two years of recovery from the low of 1982, a 2.9 per cent increase in 1983 and over 12 per cent in 1984. Such considerations suggest that fierce competition in steel markets will persist in the near future, especially if the rate of economic recovery falters and a recessionary period develops in 1985-86 as forecast by many forecasters.

Trade patterns in steel have also undergone considerable change in recent years with the entry of developing nations to international markets. This development had a disproportionate impact on the market because it occurred at a time of global excess capacity, especially in Europe.

The U.S. market was particularly susceptible to imported steel due to the increase in value of the American dollar and the relatively high cost of producing steel in the United States. Imports captured 21 per cent of the market in 1983 and had in excess of 25 per cent in the first six months of 1984. In response to low and unprofitable operating rates in combination with high levels of import penetration, companies in North America petitioned their governments for protection from low-priced imported steel. The United States won concessions from its trading partners on stainless and alloy steels in 1983, and an accord to limit exports of carbon steel to the United States was reached with the EC and Japan. In spite of these arrangements, large tonnages of imported steel, often from developing nations, continued to enter the U.S. market. Consequently, the U.S. industry increased its lobby to have imports controlled, with the result that the United States International Trade Commission (ITC) recommended that the President impose a system of tariffs and quotas. However, the President instead instructed his officals to negotiate voluntary restraint agreements with the main steel producing countries so that imports would be limited to 20.5 per cent of the U.S. market for the next five years. At year-end 1984, voluntary restaint agreements had been negociated with seven countries: Japan, South Korea, Brazil, Mexico, Spain, Austrialia and South Africa.

Anti-dumping duties were imposed on imported steel in Canada and a number of European countries.

## OUTLOOK

The consumer-led recovery that began in Canada in early 1983 resulted in a significant increase in demand for steel, especially for the sheet steel used in the production of consumer durables such as automobiles and appliances. This recovery showed signs of pausing in the last quarter of 1984. However, a slight increase in the capital investment market became evident at that time. Projects in Canada that will require significant tonnages of steel include the expansion of rail line capacity by twinning sections of railroads, the expansion of capacity for extracting oil from the tar sands, as well as a resurgence in oil exploration. These projects should increase the consumption of plate, structural, rails and tube mill products.

Canadian demand for sheet steel should also be stimulated by recent decisions to build new automobile manufacturing capacity, in the form of both new plants and expansions at existing plants. These recently announced expansions should increase steel demand even in a slower market for cars because the vehicles and parts produced will displace imports, and provide export sales under the auto pact.

Canada is expected to remain a net exporter of steel, with the bulk of it's exports going to the United States. There remains considerable potential to increase the sale of semifinished steel for rolling and further processing by U.S. firms.

Total Canadian consumption is expected to remain flat or decline slightly until the end of 1985. Growth rates to 1995 are forecast at 2 per cent per annum, reaching a 1995 total of 17.8 million t. However, a significant increase in interest rates during this period could result in a slowing of the economy and a decline in the demand for steel.

In the medium-term to 1990, an average annual increase in domestic steel production of 1.8 per cent is forecast. At this rate of growth, production should reach the level of the peak year 1979 by about 1991. The longer term rate of growth in production to 1995 is expected to be 1.7 per cent per annum.

A worldwide oversupply of steel will likely persist for the next 10 years as developing nations increase their capacity and developed nations continue to have capacity in excess of domestic consumption. The availability of low-priced imported steel will likely continue to depress the price of domestic steel in Canada.

The relative steel intensity (tonnes of steel consumption per million 1975 U.S. dollars of GNP) which dropped dramatically from the early 1970s to the early 1980s will continue to decline, but at a considerably lower rate. The downsizing of the automobile has reached a level where future size reductions will be minimal. However, materials substitution for steel will continue.

**RELATIVE STEEL INTENSITY**

| Country | 1970-73 | 1980-83 | 1990-95 |
|---|---|---|---|
| | (tonnes of steel consumption per million 1975 U.S. Dollars of GNP) | | |
| United States | 92.8 | 56.2 | 46.5 |
| Canada | 88.5 | 61.1 | 56.2 |
| Japan | 161.5 | 98.9 | 78.1 |
| United Kingdom | 116.4 | 62.4 | 50.6 |
| West Germany | 98.8 | 59.7 | 53.4 |
| Brazil | 89.5 | 72.0 | 65.7 |
| South Korea | 115.5 | 208.2 | 210.1 |

However, world supply and demand should be in better balance by the end of the decade as consumption in developing nations, which are actively building infrastructure, will consume a much higher percentages of their domestic production and the rationalization and modernization of the steel industries in developed nations will be well advanced.

Present trends that are likely to continue include: the importing of more semifabricated steel for further processing in the United States, continuing growth in the electric furnace industry because technical developments will allow such mills to make higher quality steel in a greater variety of shapes and sizes, and ongoing closures of excess capacity in industrialized nations. The remaining plants will be much more productive and efficient because of capital investment in new steelmaking technology. As the developing nations invest in the infrastructure necessary to become developed nations, more of their steel production will be consumed domestically and their need to export will be reduced. However, developing nations will continue to produce an increasing percentage of the world's steel.

## PRICES

Economic recovery and increasing demand for steel allowed the Canadian steel industry to reduce the discounting that was so prevalent during 1982. By year-end 1984, some minor price increases in flat products were in place. These increases were quite low because of the availability of low-priced imported steel, which continued to have an impact on domestic prices.

Price changes are indicated by the steel Industry Price Index (Statistics Canada, Catalogue 62-011 Iron and Steel Mills D527101 (1971=100)). For 1982, the index average was 314.7. It increased to an average of 319.2 in 1983 and was 328.4 in August of 1984.

Premium medium volatile bituminous coal, imported from the United States on a long-term contract basis, was $Cdn 80-85 a t cif Ontario steel mills in 1983, compared with $84-90 a t at year-end 1982. By year-end 1984, it was $78-80 a t.

## TABLE 1. CANADA, GENERAL STATISTICS OF THE DOMESTIC PRIMARY IRON AND STEEL INDUSTRY, 1982-84

| | | 1982 | 1983P | 1984<br>(9 Months) |
|---|---|---|---|---|
| **Production** | | | | |
| Volume indexes | | | | |
| Total industrial production | 1971=100 | 122.8 | 129.7 | 140.0 |
| Iron and steel mills[1] | 1971=100 | 106.2 | 104.2 | 120.0 |
| | | ($ million) | ($ million) | ($ million) |
| Value of shipments, iron and steel mills[1] | | 6,095.9 | 6,294.7 | 5,696,230 |
| Value of unfilled orders, year-end (Sept. in 1984), iron and steel mills | | 494.4 | 712.3 | 890,603 |
| Value of inventory owned, year-end (Sept. in 1984), iron and steel mills | | 1,741.3 | 1,858.6 | 1,942,728 |
| | | (number) | (number) | (number) |
| **Employment,** iron and steel mills[1] | | | | |
| Administrative | | 12,871 | 12,454[3] | 11,927 |
| Hourly rated | | 36,599 | 34,212 | 37,921 |
| Total | | 49,470 | 46,660 | 49,868 |
| Employment index, all employees | 1961=100 | 142.9 | .. | .. |
| Average hours per week, hourly rated | | 38.1 | 40.0 | .. |
| | | ($) | ($) | ($) |
| Average earnings per week, hourly rated | | 501.77 | 568.81 | 591.86 |
| Average salaries and wages per week, all employees | | 528.89 | 592.75 | 616.53 |
| | | ($ million) | ($ million) | ($ million) |
| **Expenditures,** iron and steel mills[1] (investment intentions in 1984) | | | | |
| Capital: on construction | | 63.1 | 17.8 | 10.4 |
| on machinery | | 381.6 | 180.5 | 216.1 |
| Total | | 444.7 | 198.3 | 226.5 |
| Repair: on construction | | 39.3 | 29.6 | 33.7 |
| on machinery | | 624.7 | 525.5 | 543.9 |
| Total | | 664.0 | 551.1 | 577.6 |
| Total capital and repair | | 1,108.7 | 753.4 | 804.1 |
| | | ($ million) | ($ million) | ($ million) |
| **Trade,** primary iron and steel[2] | | | | |
| Exports | | 1,831.4 | 1,492.9 | 1,638.2 |
| Imports | | 1,128.7 | 1,049.9 | 1,218.0 |

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Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] S.I.C. Class 291 - Iron and Steel Mills: covers the production of pig iron, steel ingots, steel castings, and primary rolled products, sheet, strip, plate, etc. [2] Includes pig iron, steel ingots, steel castings, semis, hot and cold-rolled products, pipe, wire and forgings. Excludes sponge iron, iron castings. [3] A new survey on labour statistics was started in March 1982 - statistics in later years are not fully comparable.
P Preliminary; r Revised; .. Not available.

TABLE 2. CANADA, PIG IRON PRODUCTION, SHIPMENTS, TRADE AND CONSUMPTION, 1981-83

| | 1981 | 1982 | 1983P |
|---|---|---|---|
| | | (tonnes) | |
| **Furnace capacity** January 1[1] | | | |
| Blast | 11 272 000 | 12 432 000 | 9 907 000 |
| Electric | 525 000 | 600 000 | 600 000 |
| Total | 11 797 000 | 13 032 000 | 10 507 000 |
| **Production** | | | |
| Basic iron | 9 007 942 | 7 463 457 | .. |
| Foundry iron[2] | 735 557 | 536 692 | .. |
| Total | 9 743 499 | 8 000 149 | 8 566 621 |
| **Shipments** | 738 698 | 559 529 | 530 669 |
| **Imports** | | | |
| Tonnes | 6 964 | 2 262 | 4 855 |
| Value ($000) | 1,200 | 540 | 951 |
| **Exports** | | | |
| Tonnes | 466 358 | 485 621 | 348 281 |
| Value ($000) | 101,785 | 96,420 | 69,973 |
| **Consumption** of pig iron | | | |
| Steel furnaces | 9 589 451 | 7 926 396 | 8 544 591 |
| **Consumption** of iron and steel scrap | | | |
| Steel furnaces | 7 378 826 | 5 618 834 | 6 222 820 |

Sources: Statistics Canada: Primary Iron and Steel (monthly).
[1] The capacity figures as of January 1 in each year take into account both new capacity and obsolete capacity anticipated for the year. [2] Includes malleable iron.
P Preliminary; .. Withheld to avoid disclosing company proprietary data.

TABLE 3. CANADA, CRUDE STEEL PRODUCTION, SHIPMENTS, TRADE AND CONSUMPTION, 1981-83

| | 1981 | 1982r | 1983P |
|---|---|---|---|
| | | (tonnes) | |
| **Furnace capacity**, January 1[1] | | | |
| Steel ingot | | | |
| Basic open-hearth | 3 742 250 | 3 812 250 | 3 622 250 |
| Basic oxygen converter | 11 746 200 | 12 010 340 | 12 285 640 |
| Electric | 4 526 000 | 5 367 410 | 5 387 135 |
| Total | 20 014 450 | 21 190 000 | 21 295 025 |
| Steel castings | 392 990 | 536 197 | 471 444 |
| Total furnace capacity | 20 407 440 | 21 726 197 | 21 766 469 |
| **Production** | | | |
| Steel ingot | | | |
| Basic open-hearth | 1 999 248 | 1 645 891 | 920 771 |
| Basic oxygen | 8 679 354 | 7 248 158 | 8 495 536 |
| Electric | 3 958 669 | 2 868 247 | 3 312 068 |
| Total | 14 637 271 | 11 762 296 | 12 728 375 |
| Continuously cast, included in total above | 4 770 276 | 3 894 604 | 4 801 761 |
| Steel castings[2] | 173 952 | 109 078 | 104 102 |
| Total steel production | 14 811 223 | 11 871 374 | 12 832 477 |
| Alloy steel in total | 1 659 287 | 1 032 265 | 928 306 |
| **Shipments from plants** | | | |
| Steel castings | 159 691 | 104 721 | 93 721 |
| Rolled steel products | 11 999 291 | 9 349 217 | 9 997 656 |
| Total | 12 158 982 | 9 453 938 | 10 091 377 |
| Steel ingots included with rolled steel products above | 583 705 | 816 938 | 949 655 |
| | | (000 tonnes) | |
| **Exports**, equivalent steel ingots | 3 545.2r | 3 592.9 | 2 796.8 |
| **Imports**, equivalent steel ingots | 3 412.3r | 1 214.6 | 1 346.2 |
| **Indicated consumption**, equivalent steel ingots | 14 678r | 9 493 | 10 437 |

Source: Statistics Canada.

[1] The capacity figures as of January 1 in each year take into account both new capacity and obsolete capacity anticipated for the year. [2] Produced mainly from electric furnaces.

P Preliminary; r Revised.

### TABLE 4. PRODUCER SHIPMENTS[1] OF ROLLED STEEL[2], 1982 AND 1983

| | 1982 | 1983 | Growth |
|---|---|---|---|
| | (000 tonnes) | | (per cent) |
| Ingots and semis | 525.0 | 747.7 | 42.4 |
| Rails | 412.1 | 458.6 | 11.3 |
| Wire rods | 898.0 | 1 024.9 | 14.1 |
| Structural shapes | 331.6 | 387.9 | 17.0 |
| Concrete reinforcing bar | 542.7 | 526.4 | -3.0 |
| Other hot-rolled bars | 753.1 | 850.9 | 13.0 |
| Track material | 57.2 | 50.0 | -12.6 |
| Plate | 1 122.6 | 1 014.6 | -9.6 |
| Hot-rolled sheet and strip | 1 998.9 | 2 112.7 | 5.7 |
| Cold finished bars | 68.3 | 90.0 | 31.8 |
| Cold reduced sheet, strip other and coated | 1 709.5 | 1 784.4 | 4.4 |
| Galvanized sheet | 930.2 | 949.6 | 2.1 |
| Total | 9 349.2 | 9 997.7 | 6.9 |
| Alloy steel in total shipments | 700.8 | 481.3 | -31.3 |

Source: Statistics Canada: Primary Iron and Steel (monthly).
[1] Includes producer exports. [2] Includes ingots and semis, but not steel castings; comprises both carbon and alloy steels.

### TABLE 5. DISPOSITION OF ROLLED STEEL PRODUCTS[1], 1982 AND 1983

| | 1982 | 1983 | Growth |
|---|---|---|---|
| | (tonnes) | | (per cent) |
| Wholesalers, warehouses and steel service centres | 1 230 570 | 1 551 091 | 26.0 |
| Automotive vehicles and parts | 1 082 718 | 1 640 179 | 51.5 |
| Agricultural equipment | 93 065 | 89 748 | -3.6 |
| Contractors products | 345 534 | 400 053 | 15.8 |
| Metal building systems | 38 351 | 38 572 | 0.6 |
| Structural steel fabricators | 666 223 | 717 438 | 7.7 |
| Containers | 404 365 | 412 345 | 2.0 |
| Machinery and tools | 343 977 | 367 626 | 6.9 |
| Wire, wire products and fasteners | 596 678 | 775 804 | 30.0 |
| Natural resources and extractive industries | 177 869 | 154 767 | -13.0 |
| Appliances and utensils | 92 886 | 119 643 | 28.8 |
| Stamping, pressing and coating | 336 595 | 390 767 | 16.1 |
| Railway operating | 245 800 | 286 803 | 16.7 |
| Railroad cars and locomotives | 53 126 | 50 193 | -5.5 |
| Shipbuilding | 25 634 | 18 732 | -26.9 |
| Pipes and tubes | 1 095 312 | 1 039 508 | -5.1 |
| Miscellaneous | 47 671 | 39 875 | -16.4 |
| Total domestic shipments | 6 876 374 | 8 093 144 | 17.7 |
| Producer exports[2] | 2 472 843 | 1 904 512 | -23.0 |
| Total producer shipments | 9 349 217 | 9 997 656 | 6.9 |

Sources: Statistics Canada; Primary Iron and Steel (monthly).
[1] Includes ingots and semis, but excludes steel castings, pipe and wire. [2] Total rolled steel exports amounted to 2 819.7 and 2 283.6 million t in 1982 and 1983, respectively.

**TABLE 6. CANADA, VALUE[1] OF TRADE IN STEEL CASTINGS, INGOTS, ROLLED AND FABRICATED PRODUCTS, 1981-83**

| | Imports | | | Exports | | |
|---|---|---|---|---|---|---|
| | $1981^r$ | $1982^r$ | $1983^p$ | $1981^r$ | $1982^r$ | $1983^p$ |
| | | | ($000) | | | |
| Steel castings | 41,009 | 26,178 | 24,295 | 16,092 | 13,144 | 7,657 |
| Steel forgings | 30,017 | 23,569 | 24,554 | 80,743 | 71,223 | 72,575 |
| Steel ingots | 25,379 | 3,028 | 1,523 | 53,499 | 20,837 | 31,456 |
| Rolled products | | | | | | |
| Semis | 33,687 | 8,795 | 12,062 | 209,695 | 51,296 | 133,746 |
| Other | 1,406,682 | 642,086 | 669,783 | 1,035,416 | 1,182,381 | 876,329 |
| Fabricated | | | | | | |
| Pipe and tube | 465,424 | 365,823 | 246,543 | 524,521 | 298,889 | 179,499 |
| Wire | 76,300 | 58,792 | 70,166 | 100,093 | 94,925 | 121,667 |
| Total steel | 2,078,498 | 1,128,271 | 1,048,926 | 2,020,059 | 1,732,695 | 1,422,929 |

Source: Statistics Canada.

[1] The values in this table correspond with the tonnages shown in Table 7.

$^p$ Preliminary; $^r$ Revised.

**TABLE 8. CANADA, TRADE IN STEEL[1] BY COUNTRY, 1981-83**

| | Imports | | | Exports | | |
|---|---|---|---|---|---|---|
| | $1981^r$ | $1982^r$ | $1983^p$ | $1981^r$ | $1982^r$ | $1983^p$ |
| | | | (000 tonnes) | | | |
| United States | 1 138.3 | 462.8 | 586.8 | 2 880.1 | 1 711.9 | 2 343.9 |
| ECSC[2] countries | 1 041.3 | 320.7 | 370.1 | 101.8 | 364.9 | 55.6 |
| Japan | 419.3 | 230.6 | 188.3 | 1.0 | 7.9 | 1.3 |
| Other | 509.1 | 232.9 | 191.2 | 598.4 | 1 148.7 | 296.1 |
| Total | 3 108.0 | 1 247.0 | 1 336.4 | 3 581.3 | 3 233.4 | 2 696.9 |

Source: Statistics Canada.

[1] Comprised of steel castings, ingots, semis, finished steel, forgings, pipe and wire.

[2] European Coal and Steel Community includes the European Economic Community members (Belgium, Denmark, France, Ireland, Italy, Luxembourg, Netherlands, United Kingdom, West Germany and effective 1981, Greece).

$^p$ Preliminary; $^r$ Revised.

**TABLE 7. CANADA, TRADE IN STEEL BY PRODUCT[1], 1981-83**

| | Imports | | | Exports | | |
|---|---|---|---|---|---|---|
| | 1981 | 1982$^r$ | 1983$^P$ | 1981$^r$ | 1982$^r$ | 1983$^P$ |
| | | | (000 tonnes) | | | |
| 1. Steel castings (including grinding balls) | 23.7 | 13.6 | 15.2 | 13.7 | 8.1 | 4.1 |
| 2. Ingots | 72.0 | 4.3 | 1.7 | 220.5 | 81.5 | 122.7 |
| 3. Semi-finished steel blooms, billets, slabs | 95.0 | 12.2 | 35.4 | 674.1 | 176.7 | 456.3 |
| 4. Total (1+2+3) | 190.7 | 30.1 | 52.3 | 908.3 | 266.3 | 583.1 |
| 5. Finished steel | | | | | | |
| A) Hot-rolled | | | | | | |
| Rails | 35.0 | 25.7 | 16.1 | 174.1 | 94.6 | 25.2 |
| Wire rods | 195.0 | 112.9 | 137.2 | 323.9 | 342.7 | 276.5 |
| Structurals | 364.4 | 120.4 | 162.2 | 264.5 | 201.4 | 226.8 |
| Bars | 127.2 | 95.4 | 127.5 | 265.3 | 204.5 | 275.6 |
| Track material | 6.8 | 6.0 | 4.0 | 18.2 | 12.3 | 13.0 |
| Plate | 662.9 | 213.1 | 144.2 | 287.4 | 238.3 | 139.6 |
| Sheet and strip | 654.4 | 100.9 | 135.9 | 246.1 | 630.8 | 251.5 |
| Total hot-rolled | 2 045.7 | 674.4 | 727.1 | 1 579.5 | 1 724.6 | 1 208.2 |
| B) Cold-rolled | | | | | | |
| Bars | 18.6 | 11.3 | 13.4 | 18.4 | 19.3 | 26.6 |
| Sheet and strip | 153.2 | 59.3 | 70.6 | 99.7 | 308.5 | 76.9 |
| Galvanized | 110.9 | 62.3 | 56.5 | 156.2 | 345.3 | 209.0 |
| Other[1] | 152.2 | 104.8 | 128.7 | 176.6 | 163.8 | 183.9 |
| Total cold-rolled | 434.9 | 237.7 | 269.2 | 450.9 | 336.9 | 496.4 |
| 6. Total finished steel (A+B) | 2 480.6 | 912.1 | 996.3 | 2 030.4 | 2 561.5 | 1 704.6 |
| 7. Total rolled steel (2+3+6) | 2 647.6 | 928.6 | 1 033.4 | 2 925.0 | 2 819.7 | 2 283.6 |
| 8. Total steel (4+6) | 2 671.3 | 942.2 | 1 048.6 | 2 938.7 | 2 827.8 | 2 287.7 |
| 9. Total steel (raw steel equivalent)[2] | 3 412.3 | 1 214.6 | 1 346.2 | 3 545.2 | 3 592.9 | 2 796.8 |
| 10. Fabricated steel products | | | | | | |
| Steel forgings | 6.3 | 5.8 | 7.1 | 41.3 | 32.2 | 34.1 |
| Pipe | 365.0 | 249.7 | 217.4 | 497.1 | 277.1 | 241.6 |
| Wire | 65.4 | 49.3 | 63.3 | 104.2 | 96.3 | 133.5 |
| 11. Total fabricated | 436.7 | 304.8 | 287.8 | 642.6 | 405.6 | 409.2 |
| 12. Total castings, rolled steel and fabricated (8+11) | 3 108.0 | 1 247.0 | 1 336.4 | 3 581.3 | 3 233.4 | 2 696.9 |

Source: Statistics Canada.

[1] Includes steel for porcelain enameling, terneplate, tinplate and silicon steel sheet and strip.

[2] Calculation: finished steel (row 6) divided by 0.77, plus steel castings, ingots and semis (row 4).

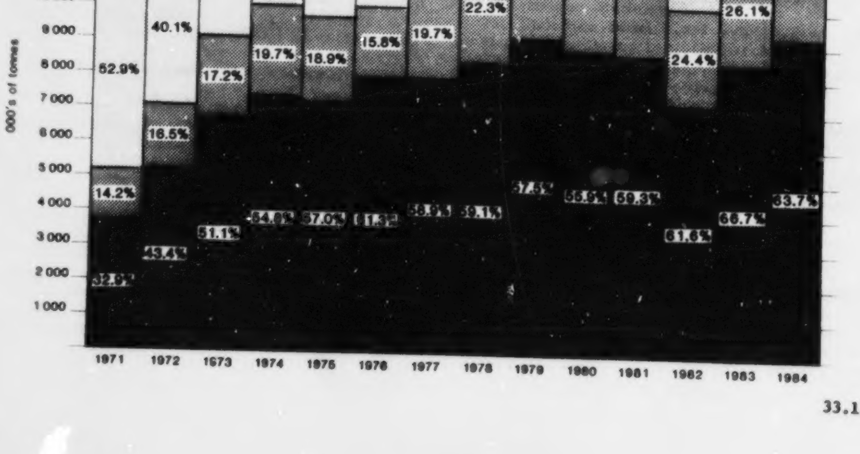
P Preliminary; r Revised.

**TABLE 9. WORLD RAW STEEL PRODUCTION, 1982 AND 1983**

|  | 1982 | 1983P |
|---|---|---|
|  | (million tonnes) |  |
| U.S.S.R. | 147.2 | 152.0 |
| Japan | 99.5 | 97.2 |
| United States | 67.6 | 76.6 |
| People's Rep. of China | 37.1 | 39.9 |
| West Germany | 35.9 | 35.7 |
| Italy | 24.0 | 21.7 |
| France | 18.4 | 17.6 |
| Poland | 14.8 | 16.4 |
| Czechoslovakia | 15.0 | 15.1 |
| United Kingdom | 13.7 | 15.0 |
| Brazil | 13.0 | 14.7 |
| Romania | 13.1 | 13.5 |
| Spain | 13.1 | 12.7 |
| South Korea | 11.8 | 11.9 |
| Canada | 11.9 | 12.8 |
| India | 11.0 | 10.3 |
| Belgium | 10.0 | 10.2 |
| East Germany | 7.2 | 7.5 |
| South Africa | 8.2 | 7.1 |
| Mexico | 7.1 | 7.0 |
| North Korea | 5.8 | 5.9 |
| Australia | 6.4 | 5.6 |
| Taiwan | 4.2 | 5.0 |
| Netherlands | 4.4 | 4.5 |
| Austria | 4.3 | 4.4 |
| Sweden | 3.9 | 4.2 |
| Yugoslavia | 3.8 | 4.1 |
| Turkey | 2.8 | 3.8 |
| Hungary | 3.7 | 3.8 |
| Luxembourg | 3.5 | 3.3 |
| Argentina | 2.9 | 2.9 |
| Bulgaria | 2.6 | 2.8 |
| Finland | 2.4 | 2.4 |
| Venezuela | 2.3 | 2.3 |
| Iran | 1.2 | 1.2 |
| Others | 11.2 | 12.7 |
| Total | 644.8 | 663.9 |

Source: International Iron and Steel Institute.
P Preliminary.
Note: Totals may not add due to rounding.

## CANADA PRODUCTION OF STEEL BY FURNACE TYPE



## TABLE 10. CANADA, ROLLED STEEL SUPPLY AND DEMAND, 1979-83

| | Producer or mill shipments[1] | Exports[2] | Imports[3] | Apparent rolled steel consumption[4] | Raw steel production[5] |
|---|---|---|---|---|---|
| | | | (000 tonnes) | | |
| 1979 | 12 230 | 2 132 | 1 811 | 11 909 | 16 078 |
| 1980 | 12 097 | 3 019 | 1 116 | 10 194 | 15 901 |
| 1981 | 11 999 | 2 925[r] | 2 648[r] | 11 722[r] | 14 811 |
| 1982 | 9 349 | 2 820[r] | 929[r] | 7 458[r] | 11 871 |
| 1983P | 9 998 | 2 284 | 1 033 | 8 747 | 12 832 |
| % Change 1983/1982 | 6.9 | -19.0 | 11.2 | 17.3 | 8.1 |

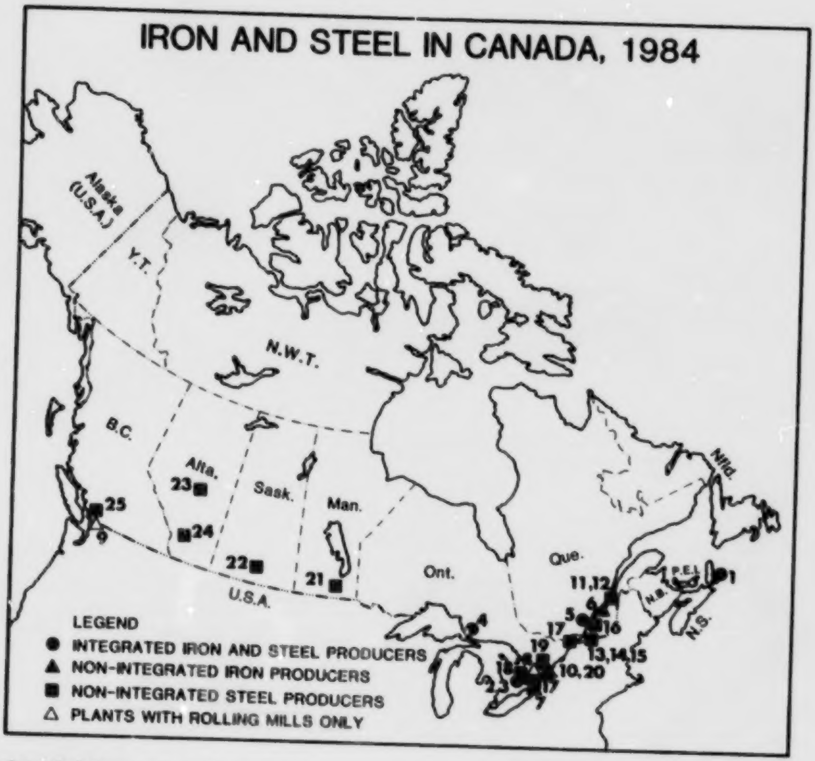
Source: Statistics Canada.
[1] Comprises domestic shipments plus producer exports. A portion of domestic shipments to warehouses and steel service centres is also exported. Excludes steel castings amounting to 200 000 t in 1979, 198 000 t in 1980, 160 000 t in 1981, 105 000 t in 1982 and 94 000 t in 1983. [2] Total exports includes producer exports plus exports from warehouses and steel service centres. Excludes exports of pipe, wire, forgings and steel castings. [3] Excludes imports of pipe, wire forgings and steel castings. [4] Excludes apparent consumption of steel castings. [5] Includes production of steel castings amounting to 223 353 t in 1979, 217 266 t in 1980, 173 952 t in 1981, 109 078 t in 1982, and 104 102 in 1983.
P Preliminary; [r] Revised.

## TABLE 11. PRICES FOR RAW MATERIALS AND SELECTED STEEL PRODUCTS, 1982 AND 1983[1]

| | Currency | 1982 | 1983 |
|---|---|---|---|
| **Raw Materials** | | | |
| Iron ore pellets, Lake Superior base price, per metric iron unit[2] | $US | 0.792-0.855 | 0.792-0.855 |
| Coal, metallurgical, imported for Ontario steel mills, per tonne | $Cdn | 91.00 | 80.50 |
| Scrap, Number 1 heavy melting, per tonne | $US | 54.95 | 77.92 |
| Direct reduced iron, per tonne | $US | 115.00 | 115.00 |
| Basic pig iron, per tonne | $US | 234.79 | 234.79 |
| Steel Price Index 1971=100 | 1981 | 1982 | 1983 |
| Structural steel shapes, unfabricated, heavy and intermediate | 290.9 | 302.9 | 303.3 |
| Steel and strip, hot rolled carbon | 281.6 | 306.5 | 316.2 |
| Sheet and strip, cold reduced, carbon, alloy and silicon | 280.1 | 308.2 | 317.2 |
| Plate, carbon and alloy | 321.4 | 351.3 | 351.9 |

Sources: Statistics Canada; Skillings Mining Review; Iron Age; Energy, Mines and Resources Canada.
[1] Prices in effect at end of December of each year. [2] One iron unit equals one per cent of a tonne. Hence, iron ore pellets with a grade of 65 per cent iron would contain 65 iron units per tonne.

IRON AND STEEL IN CANADA, 1984


Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
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25
LEGEND
● INTEGRATED IRON AND STEEL PRODUCERS
▲ NON-INTEGRATED IRON PRODUCERS
■ NON-INTEGRATED STEEL PRODUCERS
△ PLANTS WITH ROLLING MILLS ONLY

**Integrated iron and steel producers**
(numbers refer to locations on map above)

1. Sydney Steel Corporation (Sydney)
2. Dofasco Inc. (Hamilton)
3. Stelco Inc. (Hamilton and Nanticoke)
4. The Algoma Steel Corporation, Limited (Sault Ste. Marie)
5. Sidbec-Dosco Incorporated (Contrecoeur)

**Non-integrated iron producers**

6. QIT-Fer et Titane Inc. (Sorel)
7. Canadian Furnace Division of Algoma (Port Colborne)

**Plants with rolling mills only**

8. Stanley Strip Steel Division of Stanley Canada Inc. (Hamilton)
9. Pacific Continuous Steel Limited (Delta)

**Non-integrated steel producers**

10. Courtice Steel Limited
11. Stelco Inc. (Contrecoeur)
12. Atlas Steels division of Rio Algom Limited (Tracy)
13. Sorel Forge Division of Slater Steels Corporation
14. Canadian Steel Foundries Division of Hawker Siddeley Canada Inc. (Montreal)
15. Canadian Steel Wheel Limited (Montreal)
16. Sidbec-Dosco Inc. (Montreal and Longueuil)
17. Ivaco Inc. (L'Orignal)
18. Atlas Steels Division of Rio Algom Limited (Welland)
19. Hamilton Specialty Bar Division of Slater Steels Corporation (Hamilton)
20. Lake Ontario Steel Company Limited (LASCO) (Whitby)
21. Manitoba Rolling Mills division of AMACA International Limited (Selkirk)
22. IPSCO Inc. (Regina)
23. Stelco Inc. (Edmonton)
24. Western Canada Steel Limited (Calgary)
25. Western Canada Steel Limited (Vancouver)

# Lead

J. BIGAUSKAS

The non-socialist world industry in 1984 was marked by work stoppages at major mines in the United States and Australia,which in turn affected smelter operations. At the same time consumption of refined lead rose to an estimated 3.9 million t compared to 3.8 million t in 1983. The most notable increases occurred in Japan and Europe. As a result, the U.S. producer price of lead rose to an average 25.5 cents per pound - a marked improvement over 1983s 22 cent per pound average.

## CANADIAN DEVELOPMENTS

Lead is principally mined in New Brunswick, British Columbia and the Northwest Territories, but smaller amounts are also produced as a byproduct of base-metal and precious metal mines in Ontario, Manitoba and the Yukon Territory. The former major Yukon lead producer - Cyprus Anvil Mining Corporation - remained shut-down, and therefore production from this Territory in 1984 was limited. Although production from Newfoundland was reported in 1984, the closure of ASARCO Incorpo-rated's Buchans mine will likely mean that Newfoundland will no longer be a producer of lead concentrate.

Primary metallurgical works are located in Belledune, New Brunswick and Trail, British Columbia. Capacities of these plants are 72 000 tpy and 136 000 tpy of refined lead, respectively. Secondary lead plants with a combined capacity of 123 000 tpy are located in Quebec, Ontario, Manitoba, Alberta and British Columbia.

In 1984, Canadian mines produced 290 000 t of lead in concentrates, some 40 000 t more than in 1983. Production of refined lead from primary lead plants totalled 173 000 t which was 5 000 t less than in 1983. Secondary lead production rose to about 79 000 t from 58 000 t.

At the Buchans, Newfoundland copper-lead-zinc mine of Abitibi-Price Inc. (51 per cent) and ASARCO Incorporated (49 per cent), production ceased permanently in September because of exhaustion of reserves. Production had been discontinued at the 56 year-old mine in December 1981, but it was reopened in July 1983 to salvage the remaining reserves in its deepest levels.

At Brunswick Mining and Smelting Corporation Limited's No. 12 mine, planned major modifications were under way at the concentrator. The five-year program, started in 1984, will see major changes to all three concentrator lines. Substantial savings in energy costs, simplification of circuit control and reagent control are the major benefits of the project, although improved metallurgical recovery may also be an added benefit. At the mine itself, development of the 1 000 m level continued although production tonnages are mainly from 575, 725 and 850 m levels.

The Little River Joint Venture mine of Heath Steele Mines Limited and ASARCO Incorporated was shutdown in April 1983. Only limited output was obtained during 1984. Some production may come from a new open-pit in 1985.

Small quantities of lead in concentrate are produced at base-metal mines in Ontario, mainly as a byproduct of zinc and copper mining. These operations are Kidd Creek Mines Ltd.'s mines (now KCML Inc.); Mattabi Mines Limited's operation and Noranda Inc.'s Lyon Lake and "F" Group mines near Sturgeon Lake; and Noranda Inc.'s Geco Division near Manitouwadge. Similarly, in Manitoba,Hudson Bay Mining and Smelting Co. Limited recovers lead concentrates from its zinc and copper mines.

British Columbia's Sullivan Mine continues to produce substantial amounts of lead for the smelting operation at Trail, British Columbia. Pillar extraction from the mechanized sections of the mine have displaced conventional ore removal methods above the 3900 level since a program to modernize the mine began in 1978.

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Currently production by mechanized methods contributes over 60 per cent of output.

Lead-silver concentrates are produced at a number of smaller mines in British Columbia. The more notable lead producers are Teck Corporation's Beaverdell mine, Dickenson Mines Limited's Silmonac mine and Westmin Resources Limited's Lynx and Myra mines.

A promising silver-zinc-lead discovery on the Yukon-British Columbia border contains an estimated 5 million t of mineralization which averages 394 g silver and 18 per cent combined zinc and lead per t. The Midway property is owned 51 per cent by Regional Resources Ltd. and 49 per cent jointly by Canamax Resources Inc. and Procan Exploration Company. An exploration decline was begun late in 1984.

With the shutdown of Cyprus Anvil Mining Corporation's (CAMC) Faro, Yukon Territory lead-zinc mine, the Yukon Territory's production of lead was limited to lead-silver concentrates from the Elsa mine of United Keno Hill Mines Limited. CAMC began a two-year, over-burden-stripping program in June 1983 with financial assistance from the federal and the Yukon territorial governments.

In the Northwest Territories, Cominco Ltd. announced the shutdown of its Polaris zinc-lead mine for one month starting in mid-December 1984 because of low prices for its products. The Polaris mine, located on Little Cornwallis Island, has a capacity of 100 000 tpy of zinc and 30 000 tpy of lead in concentrates.

Normal operations continued at Pine Point Mines Limited's, Northwest Territories zinc-lead mine while union and company officials negotiated a new labour contract. The old agreement expired in April 1984 and a new three-year contract was settled in early-July. The company's N-81 orebody was being prepared for full production in 1986.

Cominco Ltd. has proposed the modernization and expansion of its lead smelter in Trail, British Columbia. The conventional sinter-blast furnace with a capacity of 120 000 tpy would be replaced in two stages with state-of-the-art Kivcet furnaces with total capacity of 160 000 tpy. The smelter, built originally in 1899, suffers from high energy and maintenance costs. The new Kivcet direct-smelting process would significantly improve the competitiveness of the operation.

Canadian consumption of refined lead as measured by producers' shipments estimated at 120 000 t in 1984, higher than the 96 000 t lead in 1983.

## WORLD DEVELOPMENTS

Non-socialist world consumption of refined lead from all sources rose to an estimated 3.9 million t in 1984, or 0.1 million t more than in 1983. Production of refined lead from primary and secondary lead plants in the non-socialist world also was about 3.9 million t - not significantly different from the level in 1983. Mine production of lead showed a year-over-year drop of 5 per cent to an estimated 2.3 million t of lead content.

In the United States - lengthy strikes had a major effect on operations in 1984. Mine workers at St. Joe Lead Co.'s Viburnum Division in Missouri went on strike on April 11. Subsequently, lack of feed caused the company to close its 204 000 tpy lead smelter at Herculaneum on May 18. The strike was resolved mid-December and workers were then recalled.

At Amax Lead Company of Missouri's Buick mine and Boss, Missouri lead smelter (AMAX - Homestake Lead Tollers), management personnel operated the smelter with stockpiled concentrate after workers went on strike June 1. The company was able to fulfil 50-75 per cent of its contractual requirements until October, but by November shipments were reported to be one-third of pre-strike output. On December 31,1984, the strike ended after workers accepted a three-year proposal by the company.

As a result of the indefinite shutdown of the Ozark Lead Co. mine in March 1983, feed shortages continued to affect operations at Asarco Incorporated's 100 000 tpy Glover, Missouri lead smelter. Workers went on strike at the plant at the beginning of October. Supervisory personnel operated the plant with stocks on hand and shipments were maintained at reduced levels. Terms for a new labour contract were agreed to on November 27, and the smelter was reopened the following week.

Offsetting the difficulties of these operations was the opening of St. Joe Lead Co.'s new Viburnum No. 35 lead-zinc-copper mine. About 41 000 tpy of lead in concentrate are expected to be produced from the operation.

The Mexican government has said that it intends to spend $US 1.7 billion in the mining sector as part of a major five-year plan to increase the sector's contribution to the country's GNP from 1.3 per cent to 6 per cent. The investment will mainly be made in state mining companies. Mine projects with a total capacity of some 22 000 tpy lead content are expected to start-up in 1985 and 1987. Underground development work is in progress at three other potential lead producers.

Early in March, Peru's Empresa Minera del Centro del Peru S.A. (Centromin, Peru) declared **force majeure** on refined lead shipments from its 90 000 tpy La Oroya plant because of severe rainstorms and landslides which blocked rail and road links. Shipments were resumed early in April. In July, the company once again declared **force majeure** due to a two-week strike.

Bolivia's Comporacion Minera de Bolivia (Comibol) and Empresa Nacional de Fundiciones (ENAF) completed construction of their new 22 000 tpy Kivcet lead smelter at Karachipampa in March. Start-up was delayed for the entire year because of lack of suitable feed and lack of further financing for the project.

Two mine projects were completed in Yugoslavia during 1984 - one an expansion by 4 000 tpy of lead-in-concentrate and in the other a new mine with the same capacity. Yugoslavia is currently the largest European mine producer and with continuing investments in the industry is likely to continue this role for many years.

In Italy, SAMIM S.p.A.'s planned new lead smelter with capacity of 84 000 tpy and SAMETON S.p.A.'s new electrolytic refinery are expected to start up by 1986.

In Greece, the Laurium, Attica primary lead smelter formerly owned by Pechiney Ugine Kuhlmann of France was recommissioned in February by Emmel SA. Output of 20 000 tpy of lead will be consumed domestically. The plant had been closed since 1982.

Supplies of 99.99 per cent refined lead to Europe were disrupted by a dispute over concentrate prices for Société des Fonderies de Plomb de Zellidja's 65 000 tpy lead plant in Morocco. The plant remained idle from January 1 to late-February when the government intervened to resolve the dispute.

Industrial disputes in late-March 1984 forced suspension of mine production at Broken Hill, New South Wales, Australia. This caused a shutdown of The Broken Hill Associated Smelters Pty. Ltd.'s (BHAS) 250 000 tpy lead smelter - the largest in the world - in early-May. Shipments of lead bullion were, however, maintained. Workers voted to return to work on May 18, and operations at both the mine and smelter returned to normal in mid-June.

Asian mine production, although much less significant than total metal production, rose in 1984 to some 140 000 t of lead-in-concentrate. Metal production is also expected to rise to about 475 000 t of which 210 000 t is recycled scrap. Most Asian mine and metal production presently takes place in Japan.

**PRICES**

The average U.S. producer price of refined lead, as quoted by Metals Week, was 25 cents (U.S.) per pound in January 1984 and remained around this level until June when it rose to 28 cents per pound. The average monthly price peaked in July at 30.5 cents. Thereafter the price declined to a 22 cent average in October, rose briefly in November to 25 cents and fell again to 22 cents in December. The average U.S. producer price for 1984 was 22.5 cents per pound - better than the U.S. 22 cent average in 1983.

**USES**

Lead's malleability allows it to be rolled to thicknesses of 5 cm to 0.01 mm and in varying widths and shapes for use in gaskets, washers, impact extrusion blanks, soundproofing radiation protection and architectural applications. Lead can also be extruded in the form of pipe, rod, wire or other cross-sections and can also be extruded around power cables. Flux-cored, tin-lead solders and cable sheathing are typical extrusions. The low melting point of lead allows simple casting for massive counterweights, sailboat keels and minute die castings for instruments. Type metal is noted for its ability to reproduce fine detail. Storage battery grids may be cast or rolled and together with battery posts and battery oxides represent the largest use for lead. Calcium, antimony, tin or arsenic are generally added to impart castability, strength or hardness to the alloys.

Lead shot may be used in ammunition or for mass or sound/radiation shielding where accessibility is a problem. Lead and lead alloy powder particles and flakes are added to grease and pipe joint compounds, powder metallurgy products - such as bearings, brake linings, clutch facings - solder pastes and may be incorporated into rubber and plastics for soundproofing curtains.

When added to steel, brass or bronze, lead improves machineability. Alloyed with tin, lead is used as a hot-dip coating alloy known as terne-coated steel.

Lead oxides and other compounds are also used in paints, pigments, glazes and a wide variety of chemicals. Tetraethyl lead - a gasoline additive - continues to decline in importance but still represents a significant market particularly for primary refined lead.

## OUTLOOK

Consumption of lead in the non-socialist world is expected to grow by an average 1.4 per cent per annum to the year 2000. Lead-acid batteries are expected to become an increasingly important end use as other uses, particularly tetraethyl lead, decline in relative significance. In Canada, regulations were passed limiting the amount of lead in leaded gasoline to 0.29 g/litre by January 1, 1987. The U.S. Environmental Protection Agency (EPA) has proposed a limit equivalent to 0.02 g/l by 1986. Cable sheathing will likely maintain a market niche in spite of inroads made by substitute materials. Architectural applications of sheet lead have generally been more important in European countries, although markets may develop elsewhere. Chemicals which contain lead are likely to remain fairly steady as an end-use while alloys are likely to see some decline over the next few years. Because of the increasing importance of the starting-lighting-ignition (SLI) battery as an end-use, markets are expected to become increasingly cyclical - a reflection of its product life and servicing requirements of vehicle populations.

Overall consumption growth is expected to be strongest (4.5 per cent per annum) in the Asian region particularly in the newly industrialized countries. Growth in the Japanese market is expected to be better than in the rest of the industrialized world - about 2 to 3 per cent per annum - but certainly less than the historical trend. Growth propects in Central and South America (1.8 per cent) in Africa and the Middle East (3.5 per cent) are less promising than before but will be better than in the traditional markets of Europe and the United States. Demand is expected to grow at less than 1 per cent per annum in both of these markets.

Production of refined lead in the non-socialist world is expected to rise relatively slowly to just above 4 million t in 1985, 4.4 million t in 1990 and 4.7 million t by 1995. In the year 2000 production could approach 5 million t. Projects in Italy and Peru and those known to be under consideration in Morocco, India, Iran, Taiwan and Canada may add some 250 000 tpy to metal capacity in the long term. Recycling is not expected to grow as rapidly as in the past mainly because of the expected decline in lead content of lead-acid batteries with technological improvements. Thus, mine production is expected to grow to about 2.5 million t lead content in 1985 and 2.8 million t in 1990. In the year 2000 non-socialist world mine production may exceed 3 million t of lead in concentrate.

Because of existing overcapacity at the mining and refining stages and because of relatively unoptimistic prospects for demand growth, the price of lead is not expected to return to its historical average level of 42 cents per pound (constant 1982 U.S. dollars). Nevertheless, a gradual increase to 26-27 cents per pound (constant 1982 U.S. dollars) is expected in the short-term. Increasing cost of production in the secondary sector may put upward pressure on the price of lead in the long-term to perhaps 32 cents and 34 cents per pound by 1990 and 2000, respectively.

Lead's varied markets, and producing regions, its recycleability, its joint mine production with other metals - particularly zinc and silver - are all important facets which must be considered for determining its outlook. These perhaps are reasons why the lead market is one of the most difficult to analyze. Factors which will likely be important in the future will be the increasing dependence upon the lead-acid battery as the dominant end use, slowing consumption growth in the industrialized countries in contrast to newly industrialized and developing countries, slowing expansion of the secondary industry in relation to the 1960s and 1970s, and the more optimistic outlook for zinc - a major coproduct, which comes almost entirely from mine sources.

Given all of these developments research and development on new applications for lead are clearly a priority. Recent improvements in lead-acid battery technology will ensure that it will remain the most competitive cell in the starting-lighting-ignition market. Therefore it will remain an important end-use for lead in spite of the tendency to use less lead per cell. While prospects for lead-acid traction batteries for electric vehicles are becoming more elusive, other battery applications such as utility load-levelling may still offer long-term markets. Experiments on the use of an organic lead compound as an asphalt stabilizer may lead to significant markets particularly in North America.

In the face of overcapacity and comparatively slow growth in the lead market, the key for existing producers will be to improve competitiveness of operations. Canadian mines which produce lead, on average, enjoy relatively favourable unit costs. Mining methods and equipment employed at most operations are comparatively modern. These factors in combination with Canada's well-trained labour force, make the industry one of the most competitive in the world.

Nevertheless the most important factor underlying Canada's competitive position in world lead markets is the quality of lead-bearing orebodies. Over 90 per cent of Canada's lead is produced from mixed ores in contrast to the rest of the world where only about two-thirds is produced from this source. Of course, those mines which are more reliant on lead as a source of revenue are more vulnerable to cyclical swings in lead prices.

At the smelting and refining stage, Canada is less competitive in terms of operating costs, but this is offset to some extent by recovery of byproduct silver. To improve competitiveness, modernization of smelters is being considered by the operators of both primary plants.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| CANADA | | | | | |
| 32900-1 | Ores of lead | free | free | free | free |
| 33700-1 | Lead, old scrap, pig and block | free | free | 1¢/lb | free |
| 33800-1 | Lead in bars and in sheets | 4.6% | 4.5% | 25% | 3% |
| 33900-1 | Manufacturers of lead not otherwise provided for | 14.8% | 13.9% | 30% | free[1] |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 33800-1 | 4.5 | 4.4 | 4.3 | 4.1 | 4.0 |
| 33900-1 | 13.9 | 12.9 | 12.0 | 11.1 | 10.2 |

UNITED STATES (MFN)

| | | |
|---|---|---|
| 602.10 | Lead bearing ores per lb of lead content | 0.75¢ |
| 624.02 | Lead bullion | 3.5% |
| 624.03 | Other | 3.5% |

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 624.04 | Lead waste etc. | 3.0 | 2.8 | 2.7 | 2.5 | 2.3 |

| EUROPEAN ECONOMIC COMMUNITY: (MFN) | | 1983 | Base Rate<br>(%)<br>(unless otherwise specified) | Concession Rate |
|---|---|---|---|---|
| 26.01 | Lead ores & concentrates | free | free | free |
| 78.01 | Lead unwrought | 3.5 | 3.5 | 3.5 |
| | Lead waste & scrap | free | free | free |
| JAPAN (MFN) | | | | |
| 26.01 | Lead ores & concentrates | free | free | free |
| 78.01 | Lead unwrought | | | |
| | Unalloyed | 6.8 | 7.5 | 6.0 |
| | Alloyed | 7.7 | 12.0 | 6.5 |
| | Other | 5.9 | 7.0 | 4.7 |
| | Lead waste & scrap | 3.5 | 5.0 | 3.2 |

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Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1983), USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 25, No. L 318, 1982; Customs Tariff Schedules of Japan, 1983.

[1] Pending passage by Parliament of the notice of Ways and Means motion tabled on November 12, 1981 entries entitled to the General Preferential Tariff will be accepted "Subject to Amendment".

TABLE 1. CANADA, LEAD PRODUCTION AND TRADE, 1982-84, AND CONSUMPTION 1982 AND 1983

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Production** | | | | | | |
| All forms[1] | | | | | | |
| British Columbia | 83 657 | 60,651 | 112 942 | 66,659 | 84 186 | 61,936 |
| New Brunswick | 81 475 | 59,069 | 70 346 | 41,518 | 73 250 | 53,890 |
| Northwest Territories | 63 955 | 46,367 | 81 161 | 47,901 | 88 355 | 65,003 |
| Ontario | 5 697 | 4,130 | 6 473 | 3,820 | 8 223 | 6,050 |
| Newfoundland | 1 180 | 855 | - | - | 3 527 | 2,594 |
| Yukon | 35 493 | 25,733 | 520 | 307 | 1 139 | 838 |
| Manitoba | 730 | 530 | 519 | 307 | 722 | 531 |
| Total | 272 187 | 197,335 | 271 961 | 160,512 | 259 402 | 190,842 |
| Mine output[2] | 341 212 | .. | 251 383 | .. | 290 000 | .. |
| Refined production[3] | 174 310 | .. | 178 043 | .. | 173 000 | .. |
| **Exports** | | | | | | |
| Lead contained in ores and concentrates | | | | | (Jan. - Sept. 1984) | |
| Belgium-Luxembourg | 22 387 | 8,310 | 53 545 | 9,518 | 33 303 | 7,183 |
| West Germany | 16 573 | 5,238 | 15 049 | 3,021 | 14 235 | 3,312 |
| United States | 11 401 | 4,072 | 6 440 | 2,416 | 7 194 | 2,165 |
| United Kingdom | 3 051 | 430 | 4 914 | 1,009 | 940 | 234 |
| Italy | 2 690 | 781 | 3 702 | 684 | 2 626 | 672 |
| Japan | 36 928 | 10,643 | - | - | - | - |
| Other countries | 13 714 | 5,424 | 1 810 | 418 | 1 438 | 360 |
| Total | 106 744 | 34,898 | 85 460 | 17,066 | 59 736 | 13,926 |
| Lead pigs, blocks and shot | | | | | | |
| United States | 53 105 | 34,329 | 63 661 | 35,144 | 59 300 | 41,064 |
| United Kingdom | 37 042 | 23,325 | 28 781 | 12,699 | 22 080 | 10,595 |
| Belgium and Luxembourg | 17 527 | 11,976 | 13 008 | 6,981 | 5 818 | 3,687 |
| U.S.S.R. | 10 999 | 5,797 | 12 498 | 6,337 | 1 000 | 3,729 |
| Italy | 7 179 | 4,907 | 4 736 | 2,643 | 1 963 | 1,329 |
| West Germany | 4 061 | 2,539 | 5 551 | 2,497 | 1 461 | 759 |
| Other countries | 16 213 | 11,119 | 19 030 | 10,006 | 4 817 | 2,566 |
| Total | 146 126 | 93,992 | 147 265 | 76,307 | 96 439 | 63,731 |
| Lead and alloy scrap (gross weight) | | | | | | |
| United States | 6 253 | 2,254 | 4 960 | 1,925 | 3 269 | 1,542 |
| South Korea | 731 | 167 | 756 | 165 | 136 | 66 |
| Spain | 36 | 11 | 758 | 123 | - | - |
| United Kingdom | 98 | 71 | 332 | 119 | 138 | 56 |
| West Germany | 2 242 | 758 | 363 | 96 | 394 | 149 |
| Taiwan | 550 | 174 | 125 | 25 | 473 | 82 |
| Other countries | 5 980 | 1,554 | 236 | 98 | 307 | 184 |
| Total | 15 890 | 4,989 | 7 530 | 2,551 | 4 717 | 2,081 |
| Lead fabricated materials nes | | | | | | |
| United States | 5 977 | 4,624 | 10 696 | 6,727 | 11 981 | 9,138 |
| Taiwan | 199 | 114 | 299 | 163 | - | - |
| Italy | 101 | 67 | 251 | 144 | - | - |
| Japan | 100 | 68 | 59 | 61 | 187 | 190 |
| U.S.S.R. | - | - | - | - | 500 | 300 |
| Other countries | 264 | 159 | 81 | 48 | 296 | 233 |
| Total | 6 641 | 5,032 | 11 386 | 7,143 | 12 964 | 9,851 |

TABLE 1. (cont'd)

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| | | | | | (Jan.-Sept. 1984) | |
| **Imports** | | | | | | |
| Lead pigs, blocks and shot | 5 661 | 3,894 | 2 550 | 1,642 | 4 226 | 2,961 |
| Lead oxide, dioxide and tetroxide | 839 | 938 | 1 409 | 1,419 | 857 | 980 |
| Lead fabricated materials nes | 1 753 | 2,304 | 1 298 | 1,526 | 565 | 820 |
| Lead in concentrates | 34 389 | 16,384 | 18 515 | 6,528 | 20 504 | 10,688 |
| Lead in crude ores | 22 | 5 | 34 | 5 | - | - |
| Lead in dross, skimmings and sludge | 81 | 23 | 271 | 47 | 46 | 10 |
| Lead and lead alloy scrap (gross weight) | 54 527 | 14,697 | 58 072 | 8,748 | 33 023 | 5,223 |

| | 1982 | | | 1983 | | |
|---|---|---|---|---|---|---|
| | Primary | Secondary[5] | Total | Primary | Secondary[5] | Total |
| | | | (tonnes) | | | |
| **Consumption**[4] | | | | | | |
| Lead used for, or in the production of: | | | | | | |
| Antimonial lead | 1 471$^r$ | x | x | 1 499 | x | x |
| Battery and battery oxides | 25 855$^r$ | 6 708$^r$ | 32 563$^r$ | 27 792 | 5 555 | 33 347 |
| Cable covering | x | x | x | x | x | x |
| Chemical uses; white lead, red lead, litharge, tetraethyl lead, etc. | 16 623 | 4 643 | 21 266 | 14 834 | 5 543 | 20 377 |
| Copper alloys; brass, bronze, etc. | 110 | 24 | 134 | 197 | 89 | 286 |
| Lead alloys: | | | | | | |
| solders | 1 752 | 7 495 | 9 247 | | | |
| others (including babbitt, type metals, etc.) | 64 | 14 204 | 14 268 | 1 812 | 7 633 | 9 445 |
| Semi-finished products: pipe, sheet, traps, bends, blocks for caulking, ammunition etc. | 4 217 | x | x | 4 799 | x | x |
| Other lead products | 4 944 | x | x | 2 977 | x | x |
| Total, all categories | 55 036$^r$ | 48 020$^r$ | 103 056$^r$ | 54 068 | 41 944 | 96 012 |

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Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable lead in domestic ores and concentrates exported. [2] Lead content of domestic ores and concentrates produced. [3] Primary refined lead from all sources. [4] Available data, as reported by consumers. [5] Includes all remelt scrap lead used to make antimonial lead.
P Preliminary; - Nil; .. Not available; x Confidential, but included in "other"; $^r$ Revised; nes Not elsewhere specified.

## TABLE 2. CANADA, LEAD PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975, 1979-84

| | Production | | Exports | | | | |
|---|---|---|---|---|---|---|---|
| | All forms[1] | Refined[2] | In ores and concentrates | Refined | Total | Imports Refined[3] | Consumption[4] |
| | | | (tonnes) | | | | |
| 1970 | 353 063 | 185 637 | 186 219 | 138 637 | 324 856 | 1 995 | 84 765 |
| 1975 | 349 133 | 171 516 | 211 909 | 110 882 | 322 791 | 1 962 | 89 193 |
| 1979 | 310 745 | 183 769 | 151 485 | 117 992 | 269 477 | 2 133 | 98 018 |
| 1980 | 251 627 | 162 463 | 147 008 | 126 539 | 273 547 | 2 602 | 106 836 |
| 1981 | 268 556 | 168 450 | 146 090 | 119 815 | 265 905 | 9 220 | 110 931 |
| 1982 | 272 187 | 174 310 | 106 744 | 146 126 | 252 870 | 5 661 | 103 056r |
| 1983 | 271 961 | 178 043 | 85 460 | 147 265 | 232 725 | 2 550 | 96 012 |
| 1984P | 259 402 | 173 000 | 59 736[5] | 96 439[5] | 156 175[5] | 4 226[5] | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus the estimated recoverable lead in domestic ores and concentrates exported.
[2] Primary refined lead from all sources.
[3] Lead in pigs and blocks.
[4] Consumption of lead, primary and secondary in origin.
[5] January to September 1984.
P Preliminary; .. Not available; r Revised.

## TABLE 3. CANADA, PRIMARY LEAD METAL CAPACITY, 1984

| Company and Location | Annual Rated Capacity (tonnes of refined lead) |
|---|---|
| Brunswick Mining and Smelting Corporation Limited<br>Belledune, New Brunswick | 72 000 |
| Cominco Ltd.<br>Trail, British Columbia | 136 000 |
| Canada total | 209 000 |

## TABLE 4. LEAD-PRINCIPAL USES, NON-SOCIALIST WORLD, 1983

| | Europe[e] | United States | Japan |
|---|---|---|---|
| | | (per cent) | |
| Batteries | 40 | 70 | 58 |
| Cable Sheathing | 5 | 1 | 6 |
| Pipe and Sheet | 20 | 2 | 5 |
| Chemicals[1] | 25 | 15 | 19 |
| Alloys | 5 | 5 | 4 |
| Other | 5 | 7 | 8 |

[1] Including tetraethyl lead.
[e] Estimated.

## TABLE 5. MONTHLY AVERAGE LEAD PRICES

| | United States Producer | Canadian Producer | LME Settlement |
|---|---|---|---|
| 1983 | (U.S. ¢ per lb) | (Cdn. ¢ per lb) | (£ per tonne) |
| January | 22.0 | 27.8 | 302 |
| February | 21.1 | 26.3 | 297 |
| March | 20.7 | 25.8 | 297 |
| April | 21.2 | 25.8 | 298 |
| May | 20.2 | 24.8 | 276 |
| June | 19.4 | 24.0 | 264 |
| July | 19.3 | 24.5 | 264 |
| August | 19.4 | 23.9 | 265 |
| September | 21.7 | 26.4 | 270 |
| October | 25.4 | 30.8 | 280 |
| November | 25.2 | 30.8 | 274 |
| December | 24.4 | 30.5 | 280 |
| Year Average | 21.7 | 26.8 | 280 |
| 1982 | | | |
| January | 25.1 | 31.2 | 282 |
| February | 24.1 | 30.0 | 280 |
| March | 25.0 | 31.1 | 316 |
| April | 26.4 | 33.0 | 339 |
| May | 25.4 | 33.0 | 326 |
| June | 28.2 | 34.8 | 352 |
| July | 30.5 | 41.5 | 374 |
| August | 28.2 | 38.0 | 356 |
| September | 24.2 | 33.4 | 320 |
| October | 22.3 | 31.5 | 339 |
| November | 25.2 | 33.4 | 356 |
| December | 21.9 | 31.2 | 350 |
| Year Average | 25.5 | 33.5 | 332 |

Source: Metals Week, Northern Miner.

## TABLE 6. CANADA, LEAD-BEARING DEPOSITS CONSIDERED MOST PROMISING FOR FUTURE PRODUCTION

| Company and Location | Deposit Name | Indicated Tonnage (000 tonnes) | Per Cent Lead | Lead Content (000 tonnes) |
|---|---|---|---|---|
| **New Brunswick** | | | | |
| Billiton Canada Ltd. and Gowganda Resources Inc. | Restigouche | 2 200 | 5.13 | 112 |
| Caribou-Chaleur Bay Mines Ltd. | Caribou | 44 600 | 1.70 | 757 |
| Cominco Ltd. | Stratmat 61 | 2 040 | 2.44 | 50 |
| Key Anacon Mines Limited | Middle Landing | 1 690 | 3.03 | 51 |
| KCML Inc. and Bay Copper Mines Limited | Halfmile Lake | 14 000 | 2.52 | 340 |
| | | 64 530 | 2.03 | 1 310 |
| **British Columbia** | | | | |
| Regional Resources Ltd./Canamax Resources Inc./Procan Exploration Company | Midway Project | 3 900 | 6.0* | 230 |
| Cyprus Anvil Mining Corporation | Cirque | 36 000 | 2.2 | 800 |
| | | 39 900 | 2.6 | 1 030 |
| **Yukon Territory** | | | | |
| Cyprus Anvil Mining Corporation | DY Zone | 21 000 | 5.6 | 1 296 |
| | Swim Lake | 4 500 | 4.0 | 180 |
| Hudson Bay Mining and Smelting Co., Limited | Tom | 8 000 | 8.6 | 690 |
| Aberford Resources Ltd. and Ogilvie Joint Venture | Jason | 14 100 | 7.09 | 997 |
| Placer Development Limited and United States Steel Corporation | Howard's Pass | 120 000 | 2.1 | 2 500 |
| Sulpetro Minerals Limited and Sovereign Metals Corporation | MEL | 5 000 | 2.0 | 100 |
| | | 172 600 | 3.3 | 5 763 |
| **Northwest Territories** | | | | |
| Cadillac Explorations Limited | Prairie Creek | 1 800 | 17.16 | 311 |
| Cominco Ltd. and Bathurst Norsemines Ltd. | Seven deposits | 19 000 | 0.75 | 140 |
| KCML Inc. | Izok Lake | 11 000 | 1.4 | 150 |
| Westmin Resources Limited, Du Pont Canada Inc. and Phillip Brothers (Canada) Ltd. | X-25 | 3 400 | 3.3 | 110 |
| | R-190 | 1 300 | 6.2 | 79 |
| | | 36 500 | 2.2 | 790 |
| **Canada** | | 310 000 | 2.9 | 8 900 |

Canadian Reserves of Copper, Nickel, Lead, Zinc, Molybdenum, Silver and Gold, as of January 1, 1983, MR 201. Energy, Mines and Resources Canada, 1984.

* Estimated.

## TABLE 7. WESTERN WORLD LEAD STATISTICS, 1981-84

| | 1981 | 1982 | 1983 | 1984 |
|---|---|---|---|---|
| | | (tonnes) | | |
| Mine production (Pb content) | 2 463 | 2 550 | 2 446 | 2 300 |
| Metal production | | | | |
| - primary | 2 236 | 2 269 | 2 342 | 2 300 |
| - secondary[1] | 1 798 | 1 649 | 1 565 | 1 600 |
| Metal consumption[2] | 3 899 | 3 796 | 3 805 | 3 900 |

Source: International Lead and Zinc Study Group, Energy, Mines and Resources Canada estimates.

[1] Excluding recovery of secondary materials by remelting without undergoing futher treatment before re-use. [2] Total consumption of refined pig lead including the lead content of antimonial lead. Pig lead and lead alloys recovered from secondary materials by remelting alone without undergoing further treatment are excluded.

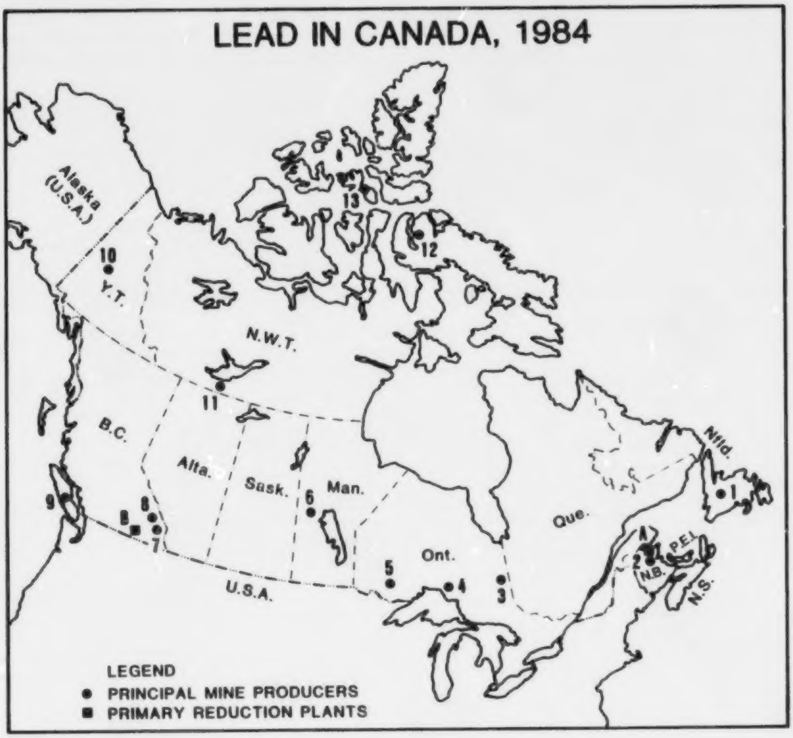
$^e$ Estimated.

## TABLE 8. NON-SOCIALIST WORLD LEAD INDUSTRY, 1984$^e$

| | Production | | | |
|---|---|---|---|---|
| | Mine | Primary Metal | Secondary[1] Metal | Consumption[2] |
| | | | (000 tonnes) | |
| Europe | 420 | 860 | 700 | 1 650 |
| North America | 64 | 640 | 560 | 1 230 |
| Central America | 220 | 140 | 30 | 100 |
| South America | 250 | 110 | 70 | 140 |
| Africa | 250 | 90 | 30 | 100 |
| Asia | 140 | 270 | 210 | 650 |
| Oceania | 400 | 190 | 30 | 70 |
| Non-socialist World | 2 320 | 2 300 | 1 630 | 3 940 |

[1] Excluding recovery of secondary meterials by remelting without undergoing further treatment before re-use. [2] Total consumption of refined pig lead including the lead content of antimonial lead. Pig lead and lead alloys recovered from secondary materials by remelting alone without undergoing further treatment are excluded.

$^e$ Estimates.


LEAD IN CANADA, 1984

Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
1
2
3
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6
7
8
9
10
11
12
13
A
B
LEGEND
● PRINCIPAL MINE PRODUCERS
■ PRIMARY REDUCTION PLANTS

**Princial mine producers**
(numbers refer to locations on map above)

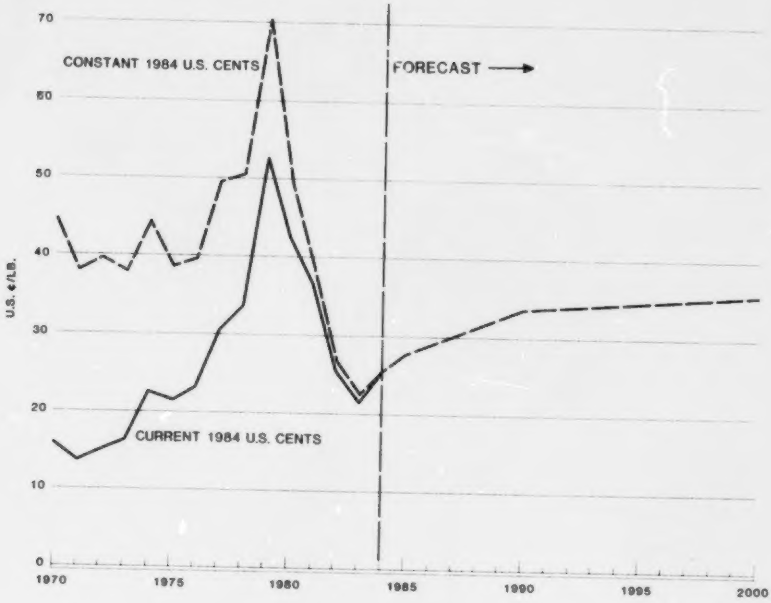
1. ASARCO Incorporated (Buchans Unit)
2. Brunswick Mining and Smelting Corporation Limited
3. Heath Steele Mines Limited (Little River Joint Venture) KCML Inc.
4. Noranda Inc. (Geco Division)
5. Mattabi Mines Limited
   Noranda Inc. (Lyon Lake, "F" Group)
6. Hudson Bay Mining and Smelting Co., Limited
7. Cominco Ltd. (Sullivan mine)
   Teck Corporation (Beaverdell mine)
8. Dickenson Mines Limited (Silmonac mine)
9. Westmin Resources Limited (Lynx and Myra)
10. United Keno Hill Mines Limited (Elsa)
11. Pine Point Mines Limited
12. Nanisivik Mines Ltd.
13. Cominco Ltd. (Polaris mine)

**Metallurgical Plants**

A. Brunswick Mining and Smelting Corporation Limited, Smelting Division, Belledune

B. Cominco Ltd., Trail

## UNITED STATES PRODUCER PRICE OF LEAD METAL 1970-2000



# Lime

D.H. STONEHOUSE

## SUMMARY 1983-84

The principal markets for lime produced in Canada are in the steel, pulp and paper and mining industries. Demand from these industries was no greater in 1983 than in 1982, but was increased marginally during 1984. Significant markets for lime have yet to develop in the environmental control field in Canada, although the possibility of use in water and sewage treatment and in the removal of sulphur dioxide from smelter gases and from thermal power plant emissions is becoming more likely.

During 1983, Domtar Inc. initiated major changes in its Lime Division. In March, Domtar sold its limestone quarrying operation on Texada Island in British Columbia to Oregon Portland Cement Company which company was subsequently taken over by Ash Grove Cement Co., now Ash Grove Cement West, Inc. The quarry will continue to supply stone to cement, pulp and paper and lime industries in both Canada and the United States. The Bellefonte, Pa. limestone and lime plant, which Domtar closed in June 1982 because of reduced demand from the steel industry, was reopened under new management (Con Lime, Inc.) in May 1983 after having been purchased in April 1983 by a local investor. In November 1983 Domtar sold its Joliette, Quebec lime plant to Jolichaux Inc., a subsidiary of Graymont Limited of Vancouver. Graymont also controls Domlim Inc. which operates plants at Lime Ridge and at St. Adolphe de Dudswell in Quebec. To complete its withdrawal from the lime business Domtar sold its lime plant and limestone quarry at Beachville, Ontario to BeachviLime Limited, effective October 1, 1984.

In late 1983, Dickenson Mines Limited announced an arrangement to acquire the assets of the Havelock Lime group of companies in Havelock, New Brunswick. Sixty per cent of the assets were to be transferred by the end of January 1984. For the next three years, Dickenson and Havelock will operate the lime works as a joint venture, after which Dickenson will take over the remaining 40 per cent.

Steetley Industries Limited expanded into the United States with the purchase of Ohio Lime Co. and of National Gypsum Company's dolomite lime plant at Gibsonburg, Ohio in 1979. In 1983, Ohio Lime Co. acquired the Millersville, Ohio plant of the J.E. Baker Co., extending Steetley's U.S. influence.

Canada's lime producing capacity remained in the order of 12 000 tpd, sufficient in quantity and well located to meet foreseeable demand.

Dolomitic limestone and magnesite deposits have been investigated as sources of magnesia. The most recent development in this area is that of Baymag Mines Co. Limited which has quarried a high-grade magnesite at Eon Mountain in British Columbia since 1982. The ore is calcined in a refurbished kiln at Canada Cement Lafarge Ltd.'s Exshaw, Alberta plant to produce caustic magnesia and refractory grade MgO. The Canadian Refractories Division of Dresser Canada Inc. has produced refractory products for many years from a magnesitic dolomite at Kilmar, Quebec.

## CANADIAN DEVELOPMENTS

Lime is a high-bulk, comparatively low-cost commodity and it is uncommon to ship it long distances when the raw material for its manufacture is available in so many localities. The preferred location for a lime plant is obviously near the principal lime markets, adjacent to a source of high-quality raw material and close to a supply of energy. The more heavily populated and industrialized provinces of Ontario and Quebec together produce over 80 per cent of Canada's total lime output, with Ontario contributing about two-thirds of Canada's

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total. Production figures do not include some captive production such as that from pulp and paper plants that burn sludge to recover lime for reuse in the causticization process.

Exports of lime from Canada have continued to decline since 1979 when over 490 000 t were exported, principally to the United States. In 1983, about 216 000 t, mainly from Ontario producers, were exported

Freight costs can represent a large part of the consumer's cost. Production costs have increased significantly as a result of higher energy costs. The industry, on average, uses about 6.4 gigajoules per t of production. New plants have incorporated preheater systems, and the need to replace some of the older less-efficient production capacity with fuel-conserving equipment is well recognized. A new-design, short-rotary kiln (65 metres) and preheater system can reduce energy consumption to about 5.1 gigajoules per t of product. The manufacturer of the new lime kiln for Domlim Inc. at St. Adolphe de Dudswell, Quebec states that with an on-line computerized process control system the "multi-column, parallel-flow, regenerative, vertical kiln" at 360 tpd rated capacity would consume less than 4.2 gigajoules per t.

Average Canadian prices for high calcium quicklime and for high calcium hydrated lime, fob plant, in bulk, were $66.14 a t and $69.06 a t respectively at the end of 1983. At mid-1984 these priceshad risen to $70.11 and $73.19 a t.

## USES

Carbonate rocks are basic to industry. They form about 15 per cent of the earth's crust and fortunately are widely distributed and easily exploitable. The principal carbonate rocks utilized by industry are limestones - sedimentary rocks composed mainly of the mineral calcite ($CaCO_3$) - and dolomites - sedimentary rocks composed mainly of ths mineral dolomite ($CaCO_3 \cdot MgCO_3$). Commonly termed limestones, they can be classified according to their content of calcite and dolomite. Their importance to the construction industry is not only as building stone and aggregate but as the primary material in the manufacture of portland cement and lime. Limestones are also used as flux material, in glass manufacture, as refractories, fillers, abrasives, soil conditioners and in the manufacture of a host of chemicals.

Quicklime (CaO or $CaO \cdot MgO$) is formed by the process of calcination, in which limestones are heated to the dissociation temperature of the carbonates (as low as 402°C for $MgCO_3$ and as high as 898°C for $CaCO_3$) and held at that temperature over sufficient time to release carbon dioxide. Although the word "lime" is used generally, and wrongly, to refer to pulverized limestone as well as to forms of burned lime, it should refer only to calcined limestone (quicklime) and its secondary products, slaked lime and hydrated lime. Slaked lime is the product of mixing quicklime and water, hydrated lime is slaked lime dried and, possibly, reground.

Calcining is done in kilns of various types, but essentially those of vertical or rotary design are used. Of comparatively recent design are the rotary hearth, travelling grate, fluo-solid and inclined vibratory types. The high cost of energy has made it imperative to include preheating facilities in any new plant design, and environmental regulations have necessitated the incorporation of dust collection equipment.

The metallurgical industry provides the largest single market for lime. With increased application of the basic oxygen furnace (BOF) in the steel industry, lime consumption increased greatly in certain areas of the United States and Canada. An increase in the demand for steel will result in the need for more fluxing lime and will encourage the development of captive sources by steel producers. The pulp and paper industry is currently the second-largest consumer of lime, most of which is used in the preparation of digesting liquor and in pulp bleaching. Any reduction of activity in either of these two industry sectors, brought on by strikes or lack of product demand, can have an immediate and serious effect on the lime industry, at least regionally. Developments in mechanical fiberizing in the pulp industry could reduce the current lime requirements of this industry significantly.

The uranium industry uses lime to control hydrogen-ion concentrations during uranium extraction, to recover sodium carbonate and to neutralize waste sludge. In the production of beet sugar, lime is used to precipitate impurities from the sucrate. It is used also in the manufacture of many materials such as calcium carbide, calcium cynamide, calcium chloride, fertilizers, insecticides, fungicides, pigments, glue, acetylene, precipitated calcium carbonate, calcium hydroxide, calcium sulphate, magnesia and magnesium metal.

The rapidly-growing concern for the safeguarding and treatment of water supplies and the appeal for enforced anti-pollution measures should result in greater use of lime for water and sewage treatment. The removal of sulphur dioxide ($SO_2$) from hydrocarbon fuels, either during the burning procedure, or from stack gases by either wet or dry scrubbing, could necessitate the use of lime. This may become a major market for this commodity as $SO_2$ emission regulations are developed. Lime is effective for this purpose, inexpensive, and can be regenerated in systems where the economics would so dictate. The creation of large amounts of gypsum waste sludge during $SO_2$ removal will present a disposal problem. Paradoxically, the lime industry is itself caught up in the clean-up campaigns sponsored by various levels of government, particularly efforts directed at dust removal.

Soil stabilization, especially for high-ways, offers a potential market for lime. However, not all soils have the physical and chemical characteristics to react properly with lime to provide a dry, impervious, cemented and stable roadbed. Hydrated lime added to asphalt hot-mix prevents the asphalt from stripping from the aggregate. This could become more important as new technologies relating to asphalt maintenance and repair are adopted and as the sources of good clean aggregate become scarce.

The use of lime-silica bricks, blocks and slabs has not been as popular in Canada as in European countries, although lightweight, cellular, insulating masonry forms have many features attractive to the building construction industry.

## OUTLOOK

The short-term outlook for the lime industry in Canada is directly related to economic recovery in general which will benefit the steel, pulp and paper and mining industries, the principal consumers of lime. In the longer term environmental legislation to control acid rain and other pollutants could have a revitalizing influence on lime production.

## TARIFFS

CANADA

| Item No. | | British Preferential | General Preferential | Most Favoured Nation | General |
|---|---|---|---|---|---|
| 29010-1 | Lime | free | free | free | 25% |

UNITED STATES (MFN)

| | | |
|---|---|---|
| 512.11 | Lime hydrated | free |
| 512.14 | Lime other | free |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1983), USITC Publication 1317.

## TABLE 1. CANADA, LIME PRODUCTION AND TRADE, 1982-84

| | 1982 | | 1983$^P$ | | 1984 | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Production**[1] | | | | | | |
| By type | | | | | | |
| Quicklime | 2 017 000 | 128,332 | 1 961 000 | .. | | |
| Hydrated Lime | 180 000 | 13,749 | 165 000 | .. | | |
| Total | 2 197 000 | 142,081 | 2 126 000 | 139,638 | 2 299 162$^e$ | 172,451$^e$ |
| By province | | | | | | |
| Ontario | 1 466 000 | 89,887 | 1 418 000 | 89,546 | | |
| Quebec | 352 000 | 26,691 | 297 000 | 21,673 | | |
| Alberta | 151 000 | 9,888 | 159 000 | 10,717 | | |
| British Columbia | 104 000 | 6,816 | 129 000 | 8,726 | | |
| Manitoba | .. | 4,838 | .. | 5,436 | | |
| New Brunswick | .. | 3,961 | .. | 3,540 | | |
| Total | 2 197 000 | 142,081 | 2 126 000 | 139,638 | 2 299 162$^e$ | 172,451$^e$ |
| | | | | | (Jan.-Sept. 1984) | |
| **Imports** | | | | | | |
| Quick and hydrated | | | | | | |
| United States | 15 875 | 1,500 | 22 822 | 2,232 | | |
| France | 88 | 43 | 22 | 41 | | |
| Total | 15 963 | 1,543 | 22 844 | 2,273 | 15 980 | 1,796 |
| **Exports** | | | | | | |
| Quick and hydrated | | | | | | |
| United States | 280 760 | 17,850 | 215 521 | 14,279 | 138 811 | 10,129 |
| Other countries | 487 | 103 | 421 | 87 | 510 | 114 |
| Total | 281 247 | 17,953 | 215 942 | 14,366 | 139 321 | 10,243 |

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments and quantities used by producers.

P Preliminary; .. Not available. $^e$ Estimated.

TABLE 2. CANADA, LIME PRODUCTION, TRADE AND APPARENT CONSUMPTION, 1970, 1975, 1978-83

| | Production[1] | | | | | |
|---|---|---|---|---|---|---|
| | Quick | Hydrated | Total | Imports | Exports | Apparent Consumption[2] |
| | | | (tonnes) | | | |
| 1970 | 1 296 590 | 224 026 | 1 520 616 | 30 649 | 181 994 | 1 369 271 |
| 1975 | 1 533 944 | 199 195 | 1 733 139 | 30 099 | 234 034 | 1 529 204 |
| 1978 | 1 857 580 | 176 631 | 2 034 211 | 31 130 | 478 552 | 1 586 789 |
| 1979 | 1 662 405 | 196 920 | 1 859 325 | 41 480 | 490 863 | 1 409 942 |
| 1980 | 2 364 000 | 190 000 | 2 554 000 | 40 901 | 403 166 | 2 191 735 |
| 1981 | 2 359 000 | 196 000 | 2 555 000 | 23 144 | 432 845 | 2 145 299 |
| 1982 | 2 017 000 | 180 000 | 2 197 000 | 15 963 | 281 247 | 1 931 716 |
| 1983P | 1 961 000 | 165 000 | 2 126 000 | 22 844 | 215 942 | 1 932 902 |

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments and quantities used by producers. [2] Production, plus imports, less exports.

P Preliminary.

TABLE 3. CANADIAN LIME INDUSTRY, 1983-1984

| Company | Plant Location | Type of Quicklime |
|---|---|---|
| **New Brunswick** | | |
| Havelock Processing Ltd. | Havelock | High-calcium[2] |
| **Quebec** | | |
| Domlim Inc. | Lime Ridge | High-calcium[2] |
| | St. Adolphe de Dudswell | High-calcium |
| Jolichaux Inc. | Joliette | High-calcium[2] |
| Quebec Sugar Refinery[1] | St.-Hilaire | High-calcium |
| **Ontario** | | |
| The Algoma Steel Corporation, Limited[1] | Sault Ste. Marie | High-calcium and dolomitic |
| Allied Chemical Canada, Ltd.[1] | Amherstburg | High-calcium |
| BeachviLime Limited | Beachville | High-calcium |
| Guelph DoLime Limited | Guelph | Dolomitic[2] |
| Timminco Limited[1] | Haley | Dolomitic |
| Domtar Inc.[3] | Beachville | High-calcium[2] |
| Reiss Lime Company of Canada, Limited | Spragge | High-calcium |
| Stelco Inc. | Ingersoll | High-calcium |
| Steetley Industries Limited | Dundas | Dolomitic |
| **Manitoba** | | |
| Alberta Sugar Company[1] | Fort Garry | High-calcium |
| Steel Brothers Canada Ltd. | Faulkner | High-calcium |
| **Alberta** | | |
| Canadian Sugar Factories Limited[1] | Taber | High-calcium |
| | Picture Butte | High-calcium |
| Steel Brothers Canada Ltd. | Kananaskis | High-calcium[2] |
| Summit Lime Works Limited | Hazell | High-calcium and dolomitic[2] |
| **British Columbia** | | |
| Steel Brothers Canada Ltd. | Kamloops | High-calcium |
| BP Resources Canada Limited | Fort Langley | High-calcium |

[1] Production for captive use. [2] Hydrated lime produced also. [3] Effective October 1, 1984 Domtar Inc. sold the Beachville plant to BeachviLime Limited.

## TABLE 4. CANADA, CONSUMPTION OF LIME, QUICK AND HYDRATED, 1981 AND 1982 (PRODUCERS' SHIPMENTS AND QUANTITIES USED BY PRODUCERS, BY USE)

| | 1981 | | 1982P | |
|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) |
| Chemical and metallurgical | | | | |
| Iron and steel plants | 1 237 519[2] | 74,529 | 940 204[2] | 60,803 |
| Pulp and paper mills | 271 945 | 16,378 | 248 298 | 16,058 |
| Water and sewage treatment | 22 760[3] | 1,371 | 85 313 | 5,517 |
| Nonferrous smelters | 117 632[2] | 7,085 | 126 597[2] | 8,187 |
| Cyanide and flotation mills | (4) | (4) | 41 412[2] | 2,678 |
| Sugar refineries | 25 841 | 1,556 | 34 729 | 2,246 |
| Other industrial[1] | 690 040 | 41,557 | 617 300 | 39.921 |
| Agricultural | 17 370 | 1,046 | 20 752[3] | 1,342 |
| Road stabilization | 9 338[3] | 565 | (4) | (4) |
| Other uses | 162 555 | 9,787 | 82 395 | 5,329 |
| Total | 2 555 000 | 153,874 | 2 197 000 | 142,081 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Includes glassworks, fertilizer plants, tanneries, uranium plants and other miscellaneous industrial uses. [2] Figures represent quicklime only. Figures for hydrated lime are included in "other industrial" to avoid disclosing confidential company information. [3] Figures represent hydrated lime only. Figures for quicklime are included in "other uses". [4] Confidential figures are included in "other industrial works".
P Preliminary.

## TABLE 5. WORLD PRODUCTION OF QUICKLIME AND HYDRATED LIME INCLUDING DEAD-BURNED DOLOMITE SOLD AND USED, 1982 AND 1983

| | 1982P | 1983[e] |
|---|---|---|
| | (000 tonnes) | |
| U.S.S.R. | 25 038 | 25 401 |
| United States | 12 802 | 13 063 |
| West Germany | 7 983 | 8 165 |
| Japan | 7 983 | 8 618 |
| Poland | 7 502 | 7 530 |
| Brazil | 4 990 | 5 171 |
| Mexico | 3 992 | .. |
| Romania | 3 538 | .. |
| France | 3 402 | 3 538 |
| East Germany | 3 538 | .. |
| Belgium | 2 722 | 2 812 |
| United Kingdom | 3 003 | .. |
| Czechoslovakia | 3 084 | .. |
| Yugoslavia | 2 707 | .. |
| Canada | 2 197 | 2 126 |
| Italy | 2 300 | 2 449 |
| Other countries | 15 175 | 36 107 |
| Total | 111 956 | 114 980 |

Sources: Energy, Mines and Resources Canada; Statistics Canada; U.S. Bureau of Mines Minerals Yearbook Preprint 1982; U.S. Bureau of Mines, Mineral Commodity Summaries, 1984.
P Preliminary; [e] Estimated; .. Included in other countries.

# Magnesium

G. BOKOVAY

After several years of weak demand and substantial cutbacks on the part of magnesium producers in the non-socialist world, market conditions for magnesium, which began to improve in the second half of 1983, continued to strengthen into 1984. With the reduction of magnesium inventory levels to more manageable levels, western world producers were estimated to be operating at about 80 per cent of installed capacity at the end of 1984 compared to an average operating rate of 63 per cent in 1983.

Magnesium consumption in 1984 is expected to be significantly higher than that recorded for 1983 and much better than the depressed conditions experienced in 1982. Although conditions have improved, increased re-cycling of aluminum alloys containing magnesium, particularly beverage cans, is one of the principal reasons for the apparent decline in the demand for magnesium since the late 1970s.

While the recovery rate for magnesium within aluminum alloy scrap is expected to increase with greater recycling, magnesium demand in other sectors will more than compensate for this declining market in the next decade. In particular, magnesium will find greater application in diecast products for the automotive industry and in desulphuriation applications in the steel industry.

As a structural material, the future for magnesium is bright as consumers re-examine the metal's desirable qualities including extremely lightweight, high strength and stiffness and excellent heat dissipation, particularly in light of recent improvements in the corrosion resistance of magnesium alloys.

Existing western world primary magnesium capacity is considered to be adequate in meeting projected demand until the end of the decade. However, if new low cost production technology being considered for introduction into Canada is successfully developed, then this could encourage the installation of additional capacity.

Whether or not the new technology becomes a reality, the magnesium industry will remain a relatively energy intensive industry and one which will increasingly view the availability of low cost energy as a major determinant for a production location decision. With a large hydroelectric potential, Canada is expected to become a much larger force in world magnesium production before the end of the century.

## CANADIAN DEVELOPMENTS

The Chromasco Division of Timminco Limited is Canada's only producer of primary magnesium. The company operates a plant at Haley, Ontario which is located about 110 kilometers west of Ottawa.

Chromasco uses the Pigeon magnesium process in which calcined dolomite is reduced by ferrosilicon in a vacuum retort. The ferrosilicon used in the process is produced by Chromasco at a plant located at Beauharnois, Quebec, while the dolomite is mined at the plant site.

Although the capacity of the individual vacuum retorts is quite low and the cost of their maintenance is reported to be quite high, the process is relatively energy efficient and the output is of extremely high purity.

Chromasco currently markets four grades of primary magnesium ranging from 99.8 to 99.98 per cent purity. As well, the corporation markets a wide range of magnesium alloys, including its AZ91X high purity diecasting alloy which contains a maximum of 0.004 per cent iron, 0.001 per cent nickel, 0.0001 copper and 0.01 per cent silicon.

In addition to magnesium, calcium and strontium are also produced at Chromasco's

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Haley plant. Magnesium capacity at the plant is estimated to be about 10 000 tpy. After operating at 60 per cent of capacity in 1983, production was gradually increased in 1984 and full production was reached in September.

In Quebec, Metamag-SNA Inc., which is 90 per cent owned by Société nationale de l'amiante, continued work in 1984 on a process to extract magnesium metal from asbestos tailings. With favourable initial test results, a new and larger pilot plant is being considered.

During 1984, MPLC (Mineral Processing Licencing Corp.) Holdings S.A. of Switzerland was reported to be holding discussions with the Province of Quebec about the possibility of constructing a new magnesium production facility. MPLC, which holds the patent to a new single stage production technology that utilizes magnesite as a feedstock for the production of magnesium chloride, claims that process is very energy efficient and will significantly lower production costs. The company plans to eventually build three 100 000 tpy capacity magnesium plants, one each to serve the U.S., European and Japanese markets. According to the company, each plant would be comprised of 10 000 tpy capacity modules each costing about $38 million. Development work on the new process is currently being carried out by MPLC at a pilot plant located near London in the United Kingdom.

The latest negotiations involving MPLC follow earlier reports that the company and the Alberta government were involved in similar negotiations. However, these discussions are reported to have been terminated.

In 1982, MPLC purchased the assets of American Magnesium Co. which had closed its 6 000 tpy capacity plant at Snyder, Texas in 1980. To date, the company has neither resumed production nor moved the plants equipment to another location. In late 1983, it was reported that MPLC was holding discussions with Interstat Resources about the possibility of using the former's technology for Interstat's Pine Flat Mountain, California orebody which contains among other commodities, 24.5 per cent magnesium oxide.

## WORLD DEVELOPMENTS

On the basis of data collected for the first half of 1984, the International Magnesium Association (IMA) expected that non-socialist world production of magnesium could reach 212 000 t for the entire year. This would represent a 24 per cent increase over the 171 000 t reported by the IMA for 1983. Current non-socialist world magnesium capacity is estimated at 262 000 tpy.

According to the IMA, magnesium inventories were drawn down by about 30 000 t in 1983 and were estimated at 24 200 t on June 30, 1984. However, inventories on September 30, 1984 were reported to have increased to 32 900 t.

The United States, which is the largest magnesium producer in the world, has three primary magnesium producers. Dow Chemical Co., the largest U.S. producer, operates a 115 000 tpy primary magnesium plant at Freeport, Texas. The plant utilizes an electrolytic process to produce magnesium from magnesium chloride from seawater.

The plant, which had been operating at around 50 per cent of capacity since the second quarter of 1982, increased production to around 65 per cent of capacity in October 1983 and to 75 per cent of capacity in July of 1984. The company had been reported to be considering incremental increases in production to year-end. In 1984, Dow completed the first phase of a modernization program started in 1980 and which included the installation of more energy efficient electrolytic cells. The modernization is reported to have resulted in some increase in capacity.

The second largest U.S. producer, Amax Magnesium Corp., operates a primary magnesium plant at Rowley, Utah. An electrolytic process is used to extract magnesium from magnesium chloride derived from the natural brines of the Great Salt Lake.

With the resurgence of magnesium demand, the Amax facility has been operating at capacity since mid-1984. The plant had operated at about 50 per cent of capacity for part of 1982 and most of 1983.

Since purchasing the plant in 1980, Amax has increased capacity to 35 000 tpy through engineering improvements and the partial startup of a fourth cell room. The company plans to increase this to over 40 000 tpy by 1986 should demand continue to improve.

Although the salinity of the Great Salt Lake has been declining because of greater runoff, the company maintains that this has not affected production.

The third U.S. producer, Northwest Alloys, a subsidiary of the Aluminum Company of America, operates a plant at Addy, Washington that uses the Magnatherm process in which magnesium is produced by reducing dolomite with ferrosilicon. The capacity of the plant is about 22 500 tpy although this will be increased to 25 000 tpy in 1985 with the addition of a tenth furnace. The plant operated at full capacity for most of 1984. It had operated at about two thirds of capacity from November 1982 to September 1983 when the first of three idled furnaces was restarted.

Norsk Hydro, the second largest non-socialist magnesium producer operates a primary magnesium plant at Porsgrunn, Norway. The plant produces magnesium by the electrolysis of magnesium chloride from seawater and magnesium brines imported from West Germany.

The Porsgrunn plant operated at about 60 per cent of capacity during 1983 at which time a major modernization program was undertaken to install new energy efficient cells. The program, which has increased capacity from 50 000 to 60 000 tpy was completed in the first half of 1984. At the end of 1984, Norsk Hydro was reportedly operating at a level of around 50 000 tpy.

The U.S.S.R. is the second largest magnesium producer inthe world, with 1983 output estimated by the U.S.B.M. at 82 500 t. The known production facilities are at Zaporozh'ye in the Ukraine, at Bereznike in the Urals and at Usf-Kamenogorsk in Kazukhstan. The U.S.S.R. is reported to have developed a new type of diaphramless magnesium electrolytic cell that significantly reduces energy requirements.

## PRICES

The U.S. price for magnesium ingot of 99.8 per cent purity, in 10 000 lb lots, as reported by American Metal Market, has risen steadily during the last several years, despite considerable variations in the level of demand and inventory levels. After remaining at $US 1.34/lb through 1982, prices increased to $1.38/lb in May 1983. In January 1984, prices increased to $1.43/lb and are currently being reported at $1.48/lb.

The price of the important diecasting alloy AZ81B at the end of 1984 was reported to be between $1.26 and $1.30/lb. With the price of secondary aluminum diecasting alloy reported to be around 60 cents US per lb, magnesium is more expensive for diecasting applications. Since on a volume basis magnesium is only two thirds the weight of aluminum, magnesium remains competitive as long as its price does not exceed 150 per cent of the price of aluminum.

At the end of 1984, Chromasco quoted a price of about $Cdn 1.84/lb for 99.8 per cent purity ingot. The price of 99.9 per cent purity ingot was $1.85 while 99.98 per cent purity ingot was $2.40. (Prices in Canada are quoted on a per kilogram basis).

## USES

According to the IMA, the largest single application for magnesium, representing over 57 per cent of non-socialist magnesium consumption in 1983, is as an alloying agent with aluminum. The addition of magnesium to aluminum imparts greater tensile strength, increased hardness, better welding properties and better corrosion resistance. One of the most important applications for aluminum alloys containing magnesium has been in beverage cans, with each can containing about 1.9 per cent magnesium. While the popularity of the aluminum can has not diminished recycling of can scrap has risen dramatically thereby reducing the demand for magnesium.

One of the potential new uses for aluminum-magnesium alloys is in the aluminum foil industry. The addition of magnesium increases the strength of the foil and thereby permits a thinner product.

The second largest use for magnesium is for structural applications of which pressure diecast products, constitute the most important component. After increasing from 21 000 t in 1982 to 28 000 t in 1983, magnesium consumption in the form of pressure diecastings is expected to reach 37 000 t in 1984 and 64 000 t in 1988.

As automobile manufacturers attempt to improve the fuel efficiency of their products, the use of lightweight parts including those of diecast magnesium is growing. Among some new automotive applications for magnesium are brake and clutch pedal support brackets, clutch housings, gear shift levers, head lamp assemblies, grill covers, air cleaner covers and valve covers. A new experimental car, manufactured by Volvo, utilizes 110 pounds of magnesium in various applications.

While the greater use of magnesium by the automobile industry is no doubt the result of the U.S. Environmental Protection Agency's fuel economy requirements, high purity magnesium alloys can be used in applications that were once considered too corrosive for the metal. In response to concern about corrosion, both Dow Magnesium and Amax in the U.S. have announced the development of new higher purity alloys and Chromasco also intends to place more emphasis on its high purity products.

Aside from automotive applications, magnesium finds application in the manufacture of portable tools, luggage and sports gear. Magnesium usage in electronic equipment and particularly computers has grown substantially and can be expected to continue.

Magnesium is also used as a deoxidizing and desulphurizing agent in the ferrous industry, and is used to produce ductile or nodular iron. Magnesium is also used as a reducing agent in the production of titanium, zirconium and other reactive metals. Pure magnesium metal is used frequently for cathodic corrosion protection of steel structures, especially underground pipes and tanks. There are many uses for magnesium in the chemical industry including the making of Grignard reagents used in the production of tetraethyl lead for gasoline, although this use has declined in recent years as government move to cut the use of these additives. Magnesium is also used in the fuel cladding material in Magnox-type nuclear reactors.

Potential new applications for magnesium that are currently being investigated include fiber-reinforced magnesium castings, hydrogen storage systems utilizing magnesium hydride, and a magnesium battery.

To support research designed to improve magnesium processing and application technology, the International Magnesium Development Corp. has been established. In particular, the corporation will be looking at new magnesium alloys and corrosion prevention.

## OUTLOOK

While there are good prospects for significant growth for magnesium usage in diecasting and desulphurizing applications, the anticipated decline in some other applications, such as aluminum alloying, alloying will moderate potential growth in demand.

As described earlier, magnesium's price is currently at a level that makes it much more expensive for diecasting applications than aluminum. Although aluminum prices are expected to recover somewhat in the next year, it is expected that aluminum markets will remain under some pressure in the medium term. Since it is likely that the magnesium prices will remain at current levels in real terms, it seems unlikely that diecasters will switch to magnesium on the basis of price alone. However, with the excellent casting characteristics of magnesium, the higher cost of the metal may be compensated by the production of thinner-walled products.

The IMA expects that by 1988, almost all North American steel plants and many in Europe will utilize magnesium desulphurization techniques. This will mean a 16 per cent increase in annual magnesium demand from this sector until then with future growth expected but a slower rate.

Overall, magnesium demand is expected to grow at an average annual rate of about 4.0 per cent until 1990 and 3.5 per cent in the 1990s.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| CANADA | | | | | |
| 35105-1 | Magnesium metal, not including alloys, in lumps, powders, ingots or blocks | 4.8 | 4.7 | 25 | 3 |
| 34910-1 | Alloys of magnesium; ingots, pigs, sheets, plates, strips, bars, rods and tubes | 4.6 | 4.5 | 25 | free |
| 34911-1 | Magnesium alloy ingots, for use in the production of magnesium castings (expires 30/6/83) | free | free | 25 | free |
| 34912-1 | Hardener alloys for use in the manufacture of magnesium castings (expires 30/6/83) | free | free | 25 | free |
| 34915-1 | Magnesium scrap | free | free | free | free |
| 34920-1 | Sheet or plate, of magnesium or alloys of magnesium, plain, corrugated, pebbled, or with a raised surface pattern, for use in Canadian manufactures (expires 30/6/83) | free | free | 25 | free |
| 34925-1 | Extruded tubing, of magnesium or alloys of magnesium, having an outside diameter of five inches or more, for use in Canadian manufactures (expires 30/6/83) | free | free | 25 | free |

| MFN Reductions under GATT (effective January 1 of year given) | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 35105-1 | Magnesium metal, not including alloys, in lumps, powders, ingots or blocks | 4.7 | 4.5 | 4.3 | 4.2 | 4.0 |
| 34910-1 | Alloys of magnesium; ingots, pigs, sheets, plates, strips, bars, rods and tubes | 4.5 | 4.4 | 4.3 | 4.1 | 4.0 |

| UNITED STATES | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 628.55 | Magnesium, unwrought, other than alloys and waste and scrap | 15 | 13.5 | 12 | 10 | 8 |
| 628.57 | Magnesium, unwrought, alloys, per pound on magnesium content | 7 | 6.8 | 6.7 | 6.6 | 6.5 |
| | | ¢ per lb of magnesium content + % ad valorem | | | | |
| 628.59 | Magnesium metal, wrought, per pound on magnesium content | 5.5¢<br>3.0% | 5.2¢<br>2.9% | 5.0¢<br>2.8% | 4.7¢<br>2.6% | 4.5¢<br>2.5% |

Sources: Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1983), USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241.

### TABLE 1. CANADA, CONSUMPTION OF MAGNESIUM, 1977-82

| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982P |
|---|---|---|---|---|---|---|
| | (tonnes) | | | | | |
| Castings and wrought products[1] | 879 | 952 | 1 447 | 1 412 | 619 | 574 |
| Aluminum alloys and other uses[2] | 5 343 | 3 001 | 3 003 | 4 000 | 5 768 | 4 431 |
| Total | 6 222 | 3 953 | 4 450 | 5 412 | 6 387 | 5 005 |

[1] Die, permanent mould and sand castings, structural shapes, tubing, forgings, sheet and plate. [2] Cathodic protection, reducing agents, deoxidizers and other alloys.
P Preliminary.

### TABLE 2. CANADIAN IMPORTS/EXPORTS OF MAGNESIUM METAL

| | Imports (t) | Exports (t) |
|---|---|---|
| 1980 | 3 419 | 5 316 |
| 1981 | 3 249 | 6 221 |
| 1982 | 1 972 | 4 501 |
| 1983 | 3 714 | 2 500 |
| 1984 (first nine months) | 2 960 | 2 653 |

Source: Statistics Canada.

### TABLE 3. WORLD PRIMARY MAGNESIUM PRODUCTION, 1981, 1982 and 1983

| | 1981 | 1982 | 1983 |
|---|---|---|---|
| | (000 tonnes) | | |
| Canada | 8.8 | 7.9 | 7.8 |
| United States | 129.9 | 89.9 | 104.7 |
| U.S.S.R.^e | 76.0 | 77.0 | 80.0 |
| Norway | 47.6 | 35.9 | 29.9 |
| France | 7.3 | 9.6 | 9.7 |
| Italy | 10.8 | 9.7 | 9.8 |
| China, P.R. | 7.0 | 7.5 | 8.5 |
| Japan | 5.7 | 5.6 | 6.0 |
| Yugoslavia | 3.9 | 4.2 | 4.7 |
| Poland | 0.5 | 0.5 | - |
| Brazil | - | 0.3 | 0.5 |
| India | 0.1 | 0.1 | 0.1 |
| Total | 297.6 | 248.4 | 261.7 |

Source: Metallgesellschaft AG.
e Estimated; - Nil.

## TABLE 4. PRIMARY MAGNESIUM PRODUCTION BY WORLD ZONE

| Period | Area 1 United States & Canada | Area 2 Latin America | Area 3 Western Europe | Area 4 Africa & Middle East | Area 5 Asia & Oceania | Total |
|---|---|---|---|---|---|---|
| | | | (tonnes) | | | |
| 1978 | 143 900 | - | 54 700 | - | 11 300 | 209 200 |
| 1979 | 156 400 | - | 58 700 | - | 11 400 | 226 500 |
| 1980 | 163 000 | - | 64 400 | - | 9 200 | 236 600 |
| 1981 | 138 400 | - | 64 400 | - | 5 700 | 208 500 |
| 1982 | 97 800 | - | 52 800 | - | 5 800 | 156 400 |
| 1983 | 109 000 | - | 51 000 | - | 6 000 | 166 000 |
| 1984 (first nine months) | 113 300 | 700 | 53 200 | - | 4 800 | 172 000 |

Source: International Magnesium Association.
- Nil.

## TABLE 5. PRIMARY PRODUCERS SHIPMENT BY WORLD ZONE

| Period | Area 1 United States & Canada | Area 2 Latin America | Area 3 Western Europe | Area 4 Africa & Middle East | Area 5 Asia & Oceania | Total |
|---|---|---|---|---|---|---|
| | | | (tonnes) | | | |
| 1982 | 85 761 | 8 347 | 60 591 | 1 278 | 17 731 | 173 708 |
| 1983 | 98 600 | 9 600 | 60 400 | 2 400 | 33 400 | 204 400 |
| 1984 (first nine months) | 84 500 | 5 700 | 49 400 | 1 100 | 21 600 | 162 300 |

Source: International Magnesium Association.

## TABLE 6. WESTERN WORLD PRIMARY MAGNESIUM CONSUMPTION PATTERN, 1983

| Use | North America | Latin America | Western Europe | Africa/ M. East | Asia/ Oceania | Total 1983 |
|---|---|---|---|---|---|---|
| | | | | (000 t) | | |
| Aluminium alloying | 53 | 2 | 34 | 2 | 26 | 117 |
| Nodular iron | 4 | | 4 | - | 1 | 9 |
| Desulphurization | 10 | .. | 2 | - | 1 | 13 |
| Chemical/reduction | 19 | 1 | 3 | - | 3 | 25 |
| Pressure diecasting | 5 | 7 | 15 | - | 1 | 28 |
| Other structural | 7 | - | 1 | - | - | 8 |
| Other | 2 | - | 1 | - | 1 | 4 |
| Total | 99 | 10 | 60 | 2 | 33 | 204 |

Source: International Magnesium Association.
- Nil.

# Manganese

**D.R. PHILLIPS**

## SUMMARY

The consumption of ferromanganese is directly related to the consumption of steel and ferrous castings. Canadian ferroalloy companies have remained competitive due to low energy costs, modern plants and technological know-how. The investment by Elkem A/S in the Canadian ferrosilicon industry, through its acquisition of Union Carbide Canada Ltd., could strengthen the latter organization's international marketing capability and make accessible the specialized ferroalloy technology necessary to remain competitive.

Manganese is essential in the production of nearly all types of steel, and approximately 95 per cent of all manganese produced is consumed by the iron and steel industry. Accordingly, the demand for manganese ores is essentially determined by the world production of iron and steel. Manganese is considered to be a strategic commodity because of its critical role in iron and steel making, for which there are no acceptable substitutes.

## CANADIAN DEVELOPMENTS

Canada has no domestic producers of manganese ore although several low-grade deposits have been identified in Nova Scotia, New Brunswick and British Columbia. The largest of these deposits, located near Woodstock, New Brunswick is reported to contain about 45 million t of mineralization grading 11 per cent manganese and 14 per cent iron. Although processes have been developed to utilize such low-grade deposits, the commercial viability of putting them in production has not been demonstrated.

The two ferromanganese producers in Canada, Elkem Metal Canada Inc. (Elkem), previously Union Carbide Canada Limited, and Timminco Limited, previously Chromasco Limited, use imported metallurgical-grade manganese ore as feed material. These companies have plants at Beauharnois, Quebec and both sell their production mainly to domestic steel producers.

Following the 1981 acquisition of the U.S. ferroalloy facilities of Union Carbide Corp., Elkem A/S exercised its legal option and acquired the assets of Union Carbide Canada Limited in 1984. Elkem planned to have its Canadian marketing office based in Toronto. The owners also negotiated a new power contract with Hydro-Québec. This acquisition by Elkem A/S could strengthen the formerly held Union Carbide organization because of Elkem A/S' worldwide operations and its strong position in international markets.

Elkem's main component of the Beauharnois plant is a 30 megawatt (MW) electric arc furnace, the largest in the western world. This furnace has a nominal capacity of 120 000 tpy of standard grade ferromanganese. However, actual production of ferromanganese is considerably less as the furnace is also used to produce silicomanganese. In 1983, the furnace was operated well below capacity but, as a result of the increased demand for steel, production was expanded in 1984 to nearly full capacity.

Timminco Limited, previously Chromasco Limited, operated its plant in Beauharnois at approximately 80 per cent of capacity in 1983 and near capacity in 1984. The plant had shut down three of its four furnaces in 1982.

Canada also imports manganese metal, an important additive in specialty steels and aluminum alloys. The main consumers of manganese metal are Atlas Steels division of Rio Algom Limited, Aluminum Company of Canada, Limited (Alcan) and Reynolds Aluminum Company of Canada Ltd.

High-purity manganese dioxide and battery-grade manganese ores are imported into Canada by various companies including

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Duracell Inc., Gould Manufacturing of Canada, Ltd. (Industrial Battery Division), Cominco Ltd. and Canadian Electrolytic Zinc Limited (CEZ).

## WORLD DEVELOPMENTS

World manganese ore production decreased about 3 per cent to an estimated 22.4 million t in 1983 from 1982, mainly due to the decreased demand from the steel industry. Ore production in 1984 was estimated to exceed that of 1983 production.

In 1983, the U.S.S.R. continued to be the world's largest producer of manganese ore, accounting for about 47 per cent of world production, followed by the Republic of South Africa, which produced approximately 13 per cent. Brazil accounted for 9 per cent of total production while the People's Republic of China, Gabon, India, Mexico and Australia collectively accounted for approximately 27 per cent of production.

South Africa remained the largest supplier of manganese to the western world by producing an estimated 2.89 million t of ore in 1983, approximately 45 per cent less than that produced in 1982. The production for 1984 was estimated to be approximately the same as 1982, which was close to capacity.

The recent acquisitions by Elkem A/S of ferroalloy facilities in the United States and Canada make it the world's largest independent ferroalloy producer.

Australian production of manganese ore in 1983 was estimated at 1.4 million t which was an increase of approximately 27 per cent over 1982. Australia is a major exporter of manganese ore and ranks in sixth place as a producer. Due to the effect of the last recession, the Australian ferromanganese industry operated at approximately 60 per cent of capacity in 1983 and 1984. Mine capacity is equivalent to approximately 2.5 million tpy of saleable ore.

Australia exported approximately 75 per cent of its manganese ore production to Europe, the U.S.S.R., Japan and the Republic of Korea. These countries normally account for approximately 90 per cent of Australian exports. The sale of ferromanganese ore to the U.S.S.R. was made by the Broken Hill Proprietary (BHP) of Australia.

The development of the Carajas manganese deposit in Brazil was reported on schedule. Trial shipments were started in late-1984 and a pier for handling the ore at Itaqui was under construction. Ore reserves at Carajas are reported to be some 60 million t grading more than 40 per cent manganese. It was estimated that the Igarape Azul Mine, also in the Carajas district, was producing sufficient manganese ore to supply the Brazilian battery industry. This mine has a production capacity of approximately one million t of manganese ore.

## USES

The excellence of manganese as a desulphurizer has made this metal an irreplaceable input in the steel industry. Sulphur in steel tends to migrate to the grain boundaries and causes steel to crack and tear during hot rolling and forming. Manganese combines with the sulphur to produce manganese sulphide inclusions, which do not migrate to the grain boundaries. The metal also acts as a deoxidizer during the steelmaking process.

Manganese is usually added to steel in the form of a ferroalloy such as ferromanganese or silicomanganese. Steel mills in Canada use about 5.8 kilograms (kg) of manganese per t of crude steel produced.

Specialty steels frequently contain manganese to increase strength and hardness. Manganese metal is normally used in preference to ferromanganese for making these specialty steels because it provides better control of the manganese and impurities content.

Hadfield steels, a type of specialty steel, contains between 10 and 14 per cent manganese. These steels are extremely hard and tough, and are particularly suited for applications such as rock crusher parts and teeth in earth-moving machinery.

Iron used for castings is desulphurized with manganese. Otherwise, the sulphur causes surface imperfections and makes precision casting difficult.

Also, manganese is used to form alloys with nonferrous metals: aluminum-manganese alloys are noted for their strength, hardness and stiffness; manganese-magnesium alloys are hard, stiff and corrosion resistant; and manganese bronzes have properties desirable in specific applications such as ship propellers.

Manganese has many nonmetallurgical applications including its use in dry-cell batteries. In this role, manganese dioxide provides oxygen to combine with hydrogen, which permits the battery to operate at maximum efficiency. Manganese ores used for batteries must grade above 85 per cent manganese dioxide and have a low iron content. Very few natural manganese dioxide ores can meet these specifications and, as a result, most batteries contain a blend of natural ore and synthetic manganese dioxide.

A common classification of manganese ores gives rise to the following ore types: (1) Manganese ores containing more than 35 per cent manganese: these are used in the manufacture of both low- and high-grade ferromanganese. Although battery-grade ores are included in this class, these ores must contain no less than 85 per cent manganese dioxide. (2) Ferruginous manganese ores containing 10 to 35 per cent manganese and used in the manufacture of spiegeleisen. (3) Manganiferous iron ores containing 5 to 10 per cent manganese and used to produce manganiferous pig iron.

All types of manganese ores can be employed in the production of manganese chemicals such as: potassium permanganate, a powerful oxidant used in the purification of public water supplies; manganese oxide, an important addition to welding rods and fluxes; and an organometallic form of manganese, which inhibits smoke formation and improves the combustion of fuel oil. Various manganese chemicals are employed to produce colour effects in face bricks and, to a lesser extent, to colour or decolour glass and ceramics.

## PRICES

Annual price negotiations for metallurgical grade manganese ore are normally concluded from April to June of each year. Prices are mainly determined on the basis of manganese content. However, several other factors including quantity, delivery schedules, tariffs and other related supply aspects of the ore are taken into account, including the physical character of the ore.

Australia's manganese producer started price negotiations in March 1983 and settled in April at $US 55.20 fob per t of high-grade manganese ore (48 per cent Mn). In the latter month the Gabonese producer concluded a price of $US 67.68 cif with Japan, and the South African producers settled for $US 67.50 cif.

Contract negotiations again progressed slowly in 1984. However, by the end of May 1984, agreement was reached at a price of $US 67.68 cif.

## OUTLOOK

The outlook for world production of manganese ore in 1985 indicates that there will be a slight increase over 1984 in response to an anticipated increased demand for steel. It is forecasted that by the year 2000, developing countries, which presently export all or most of their ore, will become increasingly involved in secondary processing.

In the long-term it is likely that the U.S.S.R. and the Republic of South Africa will continue to be the major suppliers of manganese ore. Brazil, India, Gabon, Australia and Mexico are expected to increase their share of the market. Those LDC's which have manganese reserves and low cost energy are expected to increase their ore production to meet their future domestic demand for the processing of secondary manganese products, especially ferromanganese.

World ferromanganese capacity is expected to decline within the next decade. This decline will result from a reduction of output from obsolete plants in industrialized nations, partially offset by the establishment of new efficient facilities in those countries where ore and low cost energy are available. Australia, Brazil and Mexico can be expected to substantially increase their ferroalloy capacity in the next decade.

Since manganese has no economical substitute in its main use, overall manganese ferroalloy production is projected to increase, at the rate of 1.2 per cent per year up to 1990, in parallel with growth in steel production.

Given the world reserves of manganese, the possibility of future mining of manganese modules and the decreased demand for manganese in steel and iron due to technological developments, supply shortages of manganese ore and ferromanganese are likely to develop in the foreseeable future.

## PRICES

United States prices in U.S. currency, as published by **Metals Week.**

| | December 1982 | December 1983 | December 1984 |
|---|---|---|---|
| | | $ | |
| Manganese ore, per long ton unit (22.4 lb) cif U.S. ports, Mn content | | | |
| Min. 48% Mn (low impurities) | 1.58-1.68 | 1.44-1.47 | 1.44-1.47 |
| Ferromanganese, fob shipping point, carload lots, lump, bulk | | | |
| Standard 78% Mn, per long ton | 490.00 | 490.00 | - LPS - |
| | | (cents) | |
| Medium-carbon, 80-85% Mn, per lb Mn | 46.00 | 41.00-46.00 | 41.00 |
| Silicomanganese, per lb of alloy, fob shipping point, 65-68% Mn, 16-18.5% Si, 0.2% P, 2% C | 24.50 | 21.00 | 23.50 |
| Manganese metal, per lb of product, fob shipping point | | | |
| Regular, minimum 99.5% Mn | 70.00 | 70.00 | 80.00 |
| 6% N, minimum 93.7% Mn | 80.00 | 80.00 | 86.00 |

fob Free on board; cif Cost, insurance and freight; LPS - List Price Suspended.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| CANADA | | | | | |
| 32900-1 | Manganese ore | free | free | free | free |
| 33504-1 | Manganese oxide | free | free | free | free |
| 35104-1 | Electrolytic manganese metal | free | free | 20% | free |
| 37501-1 | Ferromanganese, spiegeleisen and other alloys of manganese and iron, not more than 1% Si, on the Mn content, per lb. | free | 0.5¢ | 1.25¢ | free |
| 37502-1 | Silicomanganese, silicospiegel and other alloys of manganese and iron, more than 1% Si, on the Mn content, per lb. | free | 0.73¢ | 1.75¢ | free |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (cents) | | |
| 37501-1 | 0.5 | 0.4 | 0.4 | 0.4 | 0.4 |
| 37502-1 | 0.73 | 0.73 | 0.72 | 0.71 | 0.70 |

UNITED STATES (MFN)

| | | |
|---|---|---|
| 601.27 | Manganese ore, including ferruginous manganese ore and manganiferous iron ore, all the foregoing containing over 10% Mn | free |
| 632.30 | Manganese metal, unwrought | 14.0% |

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 606.26 | Ferromanganese, not containing over 1% C, per lb Mn content | 2.6 | 2.5 | 2.4 | 2.4 | 2.3 |
| 606.28 | Ferromanganese containing 1 to 4% C, per lb Mn content | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 |
| 606.30 | Ferromanganese containing over 4% C, per lb Mn content | 1.6 | 1.6 | 1.5 | 1.5 | 1.5 |
| 632.28 | Manganese metal waste and scrap | 9.8 | 8.8 | 7.7 | 6.7 | 5.6 |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated 1983 USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, MANGANESE, TRADE AND CONSUMPTION, 1982-84

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Imports** | | | | | (Jan.-Sept. 1984) | |
| Manganese in ores and concentrates[1] | | | | | | |
| South Africa | 10 746 | 2,011 | 8 037 | 1,112 | 20 227 | 2,539 |
| Brazil | 19 935 | 4,023 | 9 976 | 1,853 | - | - |
| United States | 3 158 | 1,209 | 3 316 | 1,166 | 2 596 | 965 |
| Gabon | 37 816 | 7,508 | 20 931 | 2,848 | 12 199 | 1,653 |
| Total | 71 655 | 14,751 | 42 260 | 6,978 | 35 022 | 5,157 |
| Manganese metal | | | | | | |
| South Africa | 430 | 769 | 2 051 | 2,961 | 1 260 | 1,829 |
| People's Republic of China | 150 | 204 | 300 | 380 | 225 | 292 |
| United States | 201 | 341 | 265 | 374 | 225 | 306 |
| Other countries | - | - | 36 | 68 | 36 | 68 |
| Total | 781 | 1,314 | 2 652 | 3,782 | 1 746 | 2,495 |
| Ferromanganese, including spiegeleisen[2] | | | | | | |
| United States | 11 319 | 11,243 | 8 498 | 8,229 | 9 099 | 6,334 |
| West Germany | - | - | 2 300 | 836 | 7 100 | 4,582 |
| South Africa | 11 335 | 5,985 | 2 031 | 1,223 | 3 676 | 7,735 |
| Mexico | 541 | 433 | 3 640 | 2,364 | 2 195 | 1,467 |
| France | 1 693 | 675 | 1 301 | 1,462 | 1 785 | 1,985 |
| Norway | 200 | 120 | 489 | 227 | 400 | 222 |
| Total | 25 088 | 18,456 | 18 259 | 14,342 | 24 255 | 16,325 |
| Silicomanganese, including silicospiegeleisen[2] | | | | | | |
| South Africa | 960 | 482 | - | - | 6 077 | 2,636 |
| Brazil | - | - | 7 | 3 | 2 | 3 |
| Norway | 1 537 | 866 | - | - | - | - |
| United States | 380 | 372 | 453 | 329 | 4 | 251 |
| Total | 2 877 | 1,720 | 460 | 332 | 6 083 | 2,890 |
| **Exports** | | | | | | |
| Ferromanganese[2] | | | | | | |
| United States | 11 440 | 4,549 | 2 631 | 902 | 1 185 | 342 |
| Puerto Rico | 157 | 81 | - | - | - | - |
| United Kingdom | 141 | 17 | - | - | - | - |
| Total | 11 738 | 4,647 | 2 631 | 902 | 1 185 | 342 |
| **Consumption** | | | | | | |
| Manganese ore | | | | | | |
| Metallurgical grade | 127 450 | .. | .. | .. | .. | .. |
| Battery and chemical grade | 3 376 | .. | .. | .. | .. | .. |
| Total | 130 826 | .. | .. | .. | .. | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Mn content; [2] Gross weight.
P Preliminary; - Nil; .. Not available.
Note: Components may not add due to rounding.

## TABLE 2. CANADA, MANGANESE IMPORTS, EXPORTS AND CONSUMPTION, 1970, 1975, 1979-83

| | Imports | | | Exports | Consumption | |
|---|---|---|---|---|---|---|
| | Manganese Ore[1] | Ferro-Manganese | Silico-Manganese | Ferro-Manganese | Ore | Ferromanganese and Silicomanganese |
| | | | (gross weight, tonnes) | | | |
| 1970 | 115 052 | 17 891 | 975 | 510 | 153 846 | 97 952 |
| 1975 | 69 773 | 35 701 | 5 732 | 1 168 | 160 976 | 95 869 |
| 1979 | 45 150 | 83 700 | 21 876 | 12 043 | 64 699 | 89 429 |
| 1980 | 95 161 | 26 704 | 20 901 | 11 278 | 157 680 | 95 796 |
| 1981 | 119 746 | 36 656 | 12 669 | 57 040 | 288 908 | 83 958 |
| 1982 | 71 655 | 25 088 | 2 877 | 11 738 | 130 826 | 69 166 |
| 1983P | 42 260 | 18 259 | 460 | 2 631 | .. | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Mn content.
P Preliminary; .. Not available.

## TABLE 3. WORLD PRODUCTION OF MANGANESE ORES, 1981-83

| | Mn | 1981 | 1982r | 1983e |
|---|---|---|---|---|
| | (%) | | (000 tonnes) | |
| U.S.S.R. | 30-33 | 9 153 | 9 824 | 10 432 |
| Republic of South Africa | 30-48+ | 5 039 | 5 216 | 2 886 |
| Brazil | 38-50 | 2 042 | 1 300 | 2 087 |
| Gabon | 50-53 | 1 488 | 1 512 | 1 857 |
| People's Republic of China[e] | 20+ | 1 597 | 1 597 | 1 597 |
| Australia | 37-53 | 1 449 | 1 132 | 1 353 |
| India | 10-54 | 1 526 | 1 448 | 1 320 |
| Mexico | 27+ | 578 | 509 | 350 |
| Ghana | 30-50 | 225 | 132 | 191 |
| Morocco | 50-53 | 110 | 94 | 74 |
| Hungary | 30-33 | 71 | 93 | 85 |
| Japan | 24-28 | 87 | 82 | 77 |
| Bulgaria | 30- | 45 | 50 | 45 |
| Yugoslavia | 30+ | 31 | 31 | 30 |
| Other countries[1] | .. | 102 | 61 | 44 |
| Total | .. | 23 543 | 23 081 | 22 428 |

Source: U.S. Bureau of Mines, "Mineral Yearbook", 1982.
[1] Includes 19 countries, each producing less than 24 000 tpy.
[e] Estimated; [r] Revised; .. Not available.

# Mica

M. PRUD'HOMME

## SUMMARY

Canadian mica shipments are estimated at 12 000 t for 1984, an increase of approximately 9 per cent over 1983. Almost 50 per cent of these shipments are exported, primarily to the United States, Japan and Europe. Since 1982, the unit value of ground mica imports rose at an average annual rate of 4 per cent, to $272.7 per t in 1984. Although fabricated mica imports have dropped by approximately 4.5 per cent per year since 1981, they should rise in 1984.

Canada is the world's leading producer of ground and flake phlogopite. Marietta Resources International Ltd., in a joint-venture with la Société Minéralurgique Laviolette Inc., operate the only active mine in Quebec's Suzor township and, in Boucherville, near Montreal, produce varieties of mica used in gypsum caulking products, in plastics and paints.

Mica production and consumption should increase in the near future. The most promising growth potential is in the plastics industry, especially for automotive applications.

## THE MICA GROUP

The micas comprise a series of phyllosilicates with a variable chemical composition, but distinct physical properties, such as basal cleavage. The term "mica" primarily refers to muscovite $KAl_2\ (AlSi_3O_{10})\ (OH)_2$, biotite $K\ (Mg,\ Fe)_3\ (Al\ Si_3O_{10})\ (OH)_2$ and phlogopite $K\ Mg_3\ (Al\ Si_3\ O_{10})\ (OH)_2$. The micas are complex hydrated aluminous silicates that crystallize in the monoclinic system.

Color varies from black to virtually colorless. Hardness is approximately 2 to 3 on Mohs' Scale, and density ranges from 2.7 to 3.1.

Essentially, only the muscovite and phlogopite varieties are of economic importance. Muscovite is a common constituent of acid igneous rock, such as granites, pegmatites and aplites. Phlogopite is particularly common in ferromagnesian basic rock, such as the pyroxenites, metasedimentary crystalline limestones, peridotites and dunites.

The micas are marketed in various forms, ranging from blocks and splittings to scrap, flake, ground and micronized mica.

Sheet mica is extracted from enormous crystals and worked by hand to obtain blocks, sheets and splittings. These grades are classified according to the size, thickness and color of the sheets. Mica sheets are valued by the electrical and electronics industries for their dielectric, optical and mechanical properties.

Scrap mica is obtained from sheet mica waste. It is generally reduced to a powder or flakes for the manufacture of mica paper and micanite or filler. These micas are classified according to particle size and are wet-ground or dry-ground. Flake mica is extracted as a coproduct of feldspath, kaolin and lithium; certain types are found in schist deposits with a high mica content.

## SITUATION IN CANADA

### Production and deposits

Canada has been producing mica since 1886; production was continuous until 1966, when the last phlogopite shipment was taken from the Blackburn mine in Cantley, Quebec. The Lacey mine near Sideham, Ontario was a major phlogopite-producing site until 1948. From 1941 to 1953, Canada was one of the largest producers of sheet muscovite, which was extracted from the Purdy mine near Mattawa, Ontario. In 1977, mica production resumed in Canada following the development of a large phlogopite deposit in Quebec's Suzor township. Since then, Canadian production has relied on a single active producer. However, since 1982, several exploration and development projects have been undertaken in Ontario and Quebec.

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The only active mine is near Parent in the township of Suzor, Laviolette county. Since 1974, Marietta Resources International Ltd., in a joint-venture with la Société Minéralurgiqu Laviolette Inc., has been exploiting a schist containing approximately 80-90 per cent phlogopite, 4-8 per cent pyroxene, 2-6 per cent perthite and traces of apatite, calcite and chlorite. Phlogopite reserves are estimated at more than 27 million t of homogenous ore to a depth of 60 m.

The ore is open-pit mined and crushed by a Kennedy Jaw crusher to smaller than 20 cm, then shipped by rail twice each year to the Boucherville processing plant near Montreal. The ore is then dry-ground, concentrated in a pneumatic separator and classified according to four sizes: -10 +20 mesh, -20 +40 mesh, -40 +100 mesh, and over 100 mesh.

Production capacity varies from 25 000 to 35 000 tpy according to the final quality. For surface-treated mica, the capacity is approximately 6 000 tpy. Flake mica, registered under the name of Suzorite, is used as a reinforcing agent in plastics and composites. The ground phlogopite varieties act as fillers in asphalt products, gypsum caulking products and drill muds.

Traces of mica have been discovered at several sites in Canada. Muscovite is particularly common in pegmatite intrusions. Interesting occurrences were located in the following Ontario townships: Addington, Calvin, Canney, Chapman, Chisholm, Christie, Clarendon, Davis, Deacon, Hungerford, Kaladar, Lennox, Mattawa, McKonkey, Olrig and Sheffield; in Quebec, muscovite is found in the counties of Abitibi-Temiscamingue, Charlevoix, Dubuc and Saguenay; in British Columbia, near Yellowhead Pass, the Big Ben district of the Columbia River, and in the Fort Grahame district.

In Canada, phlogopite is virtually confined to the northeastern belt of the Grenville series. The major occurrences of phlogopite are found in Quebec in the counties of Argenteuil, Gatineau, Hull, Labelle, Laviolette, Montcalm and Papineau, and in Ontario in the counties of Frontenac and Lanark.

**Exploration and development**

Since 1982, commercial interest in mica has intensified and led to several projects, primarily in Ontario and Quebec. In Ontario's Kaladar township, a quartzite schist deposit rich in muscovite was the focus of an exploration exploration campaign by Koizumi (Canada) Ltd. The deposit, named Kaladar Aimko Property, contains almost 60 per cent muscovite associated with quartz with traces of biotite and hematite. Approximately 5,200 short tons of bulk samples have already been shipped to Japan, where they were processed in a pilot plant to produce mica for the plastics industry. In Clarendon township, Ontario, another deposit has attracted special attention since 1980. The Ontario Ministry of Natural Resources carried out exploration work in 1982 and 1983. Pelitic schists contain approximately 40 to 50 per cent muscovite with varying amounts of biotite, feldspath, garnet, staurolite, kyanite, sillimanite and magnetite.

In Chasseur Township, Quebec, SOQUEM carried out improvement work on a deposit belonging to Provinces & Explorations Inc. Drilling estimated the reserves at approximately 380 000 t per vertical m with a 50 per cent phlogopite content. In Lamy township, exploration was undertaken; reserves have already been estimated at more than 10.2 million t of ore containing 60 to 75 per cent phlogopite. In Suzor township, on the property of Marietta Resources International Ltd., EM-6 electromagnetic surveys were carried out in 1982 and 1983 in order to determine the reserves. In Dandurand township, Frédéric Exploration collected mica samples in 1982. Mineralogical assays at the Centre de Recherche Minérale in Quebec City set the mean flake diameter at approximately 1.1 mm.

In British Columbia, a micaceous schist deposit was evaluated by Brinco under a Tournigan Mines option in 1982.

**Research and expansion**

From 1979 to 1982, the Centre de Recherche Minérale in Quebec City carried out laboratory and pilot plant research on mica processing. Various grinding and delamination techniques were tested to obtain a fine-grain material with a high diameter/thickness ratio. Since 1982, the Industrial Materials Research Institute (IMRI) of the National Research Council completed applied studies on the use of mica in thermoplastics and on resistance to fatigue of engineering plastics. In 1983, Marietta Resources International Ltd. invested approximately $1 million in an expansion program that will allow it to increase its production capacity of fine mica to approximately 15 000 tpy; this grade S mica is used to reinforce plastics in the automobile industry.

## USES AND SPECIFICATIONS

Sheet mica is used mainly in the electrical and electronics industries, and in small quantities for thermal insulation. Sheet muscovite is used to manufacture micanite, mica paper and fabricated products, such as capacitors and communicator segments. Since the dielectric properties of musconite are better than those of phlogopite, transparent mica is the most common variety used in those sectors. The specifications for sheet mica comply with the standards of the American Society for Testing and Materials (ASTM). Designation ASTM-D351-62 specifies quality according to stain, inclusions and imperfections. Designation ASTM-D2131-65 specifies the required characteristics for mica product manufacture. Designation ASTM-D748-59 defines the requirements for the electrical, physical and visual properties of the mica sheets used in capacitors.

Sheet mica is graded according to thickness: blocks must be thicker than 0.007 in. (0.18 mm), films between 0.0008 and 0.004 in., and splittings approximately 0.0011 in.

Ground and micronized micas are used as reinforcing agent or filler in drill muds. The major user industries include gypsum caulking products, asphalt roofing products, paints, rubber products and plastics.

Drywall products and joint cement compounds constitute the major utilization range for mica. Mica prevents cracking and provided good workability due to its structural quality. Product size should be less than 150 microns and be free of abrasive grits. Muscovite is occasionally preferred over phlogopite as it is virtually colorless. The principal substitutes for mica are talc, clay and asbestos.

Mica is used in asphalt roofing products as dusting agent. It is also used as a filler in asphalt mixtures to improve their resistance to weather. Dry-ground mica varies in size from 850 to 75 microns (20 to 200 mesh sieve).

Paints require fillers to improve surface qualities. Mica reduces shrinkage, prevents cracking and improves resistance to weather. It is used in exterior paints, anticorrosive emulsions and oil-based metal primers. Wet-ground or micronized mica should be transparent. Required particle sizes are of the order of 100, 160 and 325 mesh sieves, and more than 30 microns.

Producers of rubber materials use mica as a dusting and releasing agent. It is also used as a filler to reduce gas penetration and shrinkage during moulding. The mica is generally in 850 to 150 micron flakes.

Plastics are a recent application for micas. Flakes are used as a reinforcing agent along with fibrous substances, such as fiberglass, wollastonite and asbestos. Micas with a high diameter/thickness ratio (High Aspect Ratio, HAR) are used in polypropylenes, polyethylenes and phenolic plastics. The resulting plastics have high flexural and tensile strength, and low permeability and good resistance to weathering. Delaminated micas are treated with coupling agents to improve their cohesion with resins. Typical loading range from 20 to 50 per cent in plastic mixtures. These ground micas have particle size varying from 425 to 45 microns.

Other principal uses of the mica varieties include: wet-ground mica; wallpaper and lubricants, dry-ground mica; drill muds, insulating panels, welding electrodes, acoustical products, adhesives, extinguisher powders and composite cement materials.

## CONSUMPTION AND TRADE IN CANADA

In Canada, mica is primarily consumed by the construction industry. More than 90 per cent of the mica is used in gypsum caulking products and paints. The rubber, plastics and drill muds industries share the remaining 10 per cent.

Canada imports ground muscovite from the United States for asphalt roofing products and gypsum products, especially for manufacturers in the western provinces.

Canadian imports have been declining since 1981. In 1983, imports of ground and micronized mica was valued at $687,000 for a volume of 2 632 t, which account for only 19 per cent of the total import value. These imports are overshadowed by the fabricated mica products coming in equal volumes from the United States and France. More than 80 per cent of these imports were traditionally from the United States. Canadian exports to the United States have been climbing since

1982, reaching almost 4 700 t in 1983. The principal sector served is the plastics industry. Japan, Europe and South America are the other export markets for Canadian mica.

## WORLD PRODUCTION AND REVIEW

World production of mica can be broken down according to mica type. India is the most important source of sheet muscovite, followed by Brazil, Argentina and Madagascar. The United States is the largest producer - and consumer - of ground and flake mica. It produces muscovite by wet and dry methods, generally as a coproduct of kaolin, lithium or feldspath. Canada dominates the world market in the production of flake, ground and micronized phlogopite; Argentina produces a small volume of sheet phlogopite.

In 1983, the world production of mica rose by approximately 13 per cent to almost 237 000 t as a result of an increase in U.S. production, which accounts for approximately 54 per cent of the world total.

**United States:** Principal uses are gypsum caulking products (47 per cent) and paints (15 per cent). The market for gypsum products has been captive, especially since the purchase of the Diamond Mica Co. of North Carolina by U.S. Gypsum, in 1979. Harris Mining Co. and J.M. Huber Corp. will increase their production capacity in 1985 to serve the plastics industry. In 1982, Mineral Industrial Commodities of America Inc. (MICA) of New Mexico began construction of a new plant to increase its total production of ground mica.

**Finland:** Kemira Oy announced the construction of a plant that, will begin producing mica for the plastics industry in autumn 1985. This plant, which generates an investment of approximately 14.9 million Markkas, will process the phlogopite that is currently dumped from the apatite mine in Siilinjaervi.

**India:** In 1983, the Mica Trading Corporation of India Ltd. (MITCO) started work on several development projects: the production of crushed mica of the order of 1 micron, the manufacture of mica paper using Japanese technology, and the production of insulation with a mica paper base with the participation of a West German firm.

## OUTLOOK FOR THE MICA INDUSTRY

The sheet mica producers' strategy is to further develop the production of fabricated mica. These high-value-added products still require extensive manual labour, and a major change should happen in the future.

In North America, the production capacity of ground mica exceeds demand; however, optimistic forecasts of increased demand in the 1980s have resulted in work being started on several expansion projects. The economic performances of the ground and flake mica industry are linked to those of the construction, plastics, drill mud and insulation industries.

In the construction sector, manufacturers of paints, asphalt roofing products and gypsum caulking products consume more than 90 per cent of all mica used in Canada.

Capital investment and repair expenditures in the construction sector have been rising since 1982; they reached $56,370 million in 1984, an increase of 1.6 per cent over 1983. According to the Canadian Construction Association, investment in the residential sector represents 30 per cent of investment in the construction industry. In the 1984-1990 period, slow growth is anticipated, of the order of 0.2 to 0.6 per cent, i.e. a smaller increase than the average annual growth rate for the Canadian economy, estimated at 3 per cent. In the non-residential sector, which represents 25 per cent of total investment in the construction industry, average growth (estimated at 4.8 to 6.5 per cent for that period) far exceeds the average annual growth of the economy.

In Canada, the consumption of mica in construction-related industries should equal the growth rate. In the United States, demand for mica in the gypsum products and paint industries will record average increases of 3.8 per cent and 3.1 per cent, respectively, for the 1983-88 period.

The plastics industry appears to be the favored sector for any major growth in mica consumption. Mica is used in the plastics intended for the automobile sector, for which demand has been increasing for the last few years. Indeed, the quantity of plastics consumed in a standard American car rose from 162.5 pounds in 1976 to 200 pounds in 1983, and should increase to 225 pounds in 1990 and 250 pounds in 1992. The proportion of plastics in a car will rise at an average annual rate of 9.2 per cent over the 1987-92 period. Moreover, according to Chase Econometrics, the North American automobile industry should record average annual growth of 1.8 to 2.6 per cent for the 1985-90 period. In view of these increases in the demand for plastics, mica could benefit both in the short- and in the long-term from a changing market, particularly as a reinforcing agent in certain polymers (especially polypropylenes, polyurethanes and polyesters), the use of which should increase considerably in this sector. Some estimates set the consumption of mica for plastics in 1988 at four times the 1983 figure.

The oilwell drilling industry, a traditional market for mica, is relying more on mica substitutes. In the short-term, little growth is expected from this market. The insulation industry should maintain its mica consumption despite the pressure exerted by the producers of substitute materials and minerals.

## PRICES, 1983

Average price[1] for wet-ground and dry-ground mica in the United States.

| | $US per short ton |
|---|---|
| Wet-ground mica: | 397 |
| Dry-ground mica: | 118 |
| By uses: | |
| drill muds | 105 |
| paints | 164 |
| joint cement | 146 |

Prices for mica in the United States, according to the Chemical Marketing Reporter[2].

| | $US per lb |
|---|---|
| Wet-ground mica: Paints, per carload, 325 mesh sieve, fob, works | .6½ |
| Dry-ground mica: Joint cement, plastics, 50-pound bags, carload, works | .07½ |
| Dry-ground mica: Roofing products, 20 to 80 mesh sieves, point of shipping | .07 |
| By uses; carload, fob, works | |
| rubber products | .16½ |
| wallpaper | .22 |

| | $Cdn per short ton |
|---|---|
| Prices for phlogopite[3], fob, carload | |
| miconized mica | 220-380 |
| Surface-treated mica | 590-720 |
| Flake or ground mica | 225-370 |

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[1] U.S. Bureau of Mines, 1983, mica. [2] CRM, May 30, 1983. [3] Marietta Resources International Ltd., April 15, 1983.
fob Free on board.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation (MFN) | General | General Preferential |
|---|---|---|---|---|---|
| | | | (per cent) | | |
| CANADA | | | | | |
| 29600-1 | Mica schist | free | free | free | free |
| 29650-1 | Mica, phlogopite and muscovite, unmanufactured, in blocks, sheets, splittings, films, waste and scrap | free | free | 25 | free |
| 44550-1 | Raw low loss mica, sheets and punchings of low loss mica | free | free | 25 | free |
| UNITED STATES (MFN) | | | | | |
| 516.11 | Untrimmed phlogopite | | free | | |
| 516.31 | Split block mica | | free | | |
| 516.41 | Other | | free | | |
| 516.51 | Mica splittings | | free | | |
| 516.61 | Mica, not over 0.006" in thickness, not cut or stamped to dimensions, shape or form | | free | | |

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (per cent) | | |
| 516.21 | Phlogopite, waste and scrap | 5.1 | 4.9 | 4.7 | 4.4 | 4.2 |
| 516.24 | Other mica, waste and scrap | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 |
| 516.81 | Ground or pulverized mica | 5.2 | 3.8 | 3.3 | 2.9 | 2.4 |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated 1983, USITC Publication 1317; U.S. Federal Register, Vol. 44, No. 241.

Note: Various other tariffs are in effect on cut and stamped mica and on mica manfuacturing.

**TABLE 1. CANADA, MICA IMPORTS, 1981-84**

| | 1981 | | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| | | | | | | | (Jan.-Sept.) | |
| Unmanufactured, scrap and schist mica | | | | | | | | |
| United States | .. | 14 | .. | 24 | .. | 52 | .. | 39 |
| India | .. | - | .. | 134 | .. | - | .. | - |
| Subtotal | .. | 14 | .. | 158 | .. | 52 | .. | 39 |
| Ground mica | | | | | | | | |
| United States | 2 994 | 735 | 2 378 | 590 | 2 632 | 680 | 1 786 | 487 |
| Subtotal | 2 994 | 735 | 2 378 | 590 | 2 632 | 680 | 1 786 | 487 |
| Mica in blocks, films and sheets | | | | | | | | |
| United States | 138 | 270 | 481 | 250 | 157 | 191 | 78 | 106 |
| India | 1 | 1 | 1 | 2 | 1 | 6 | - | - |
| Subtotal | 139 | 271 | 482 | 252 | 158 | 197 | 78 | 106 |
| Total sheet and ground mica | 3 133 | 1,007 | 2 860 | 842 | 2 790 | 877 | 1 864 | 593 |
| Fabricated mica nes | | | | | | | | |
| United states | .. | 2,598 | .. | 2,230 | .. | 1,385 | .. | 1,688 |
| France | .. | 287 | .. | 420 | .. | 1,118 | .. | 550 |
| Great Britain | .. | 34 | .. | 88 | .. | 115 | .. | 145 |
| India | .. | 8 | | 18 | .. | 54 | .. | 28 |
| West Germany | .. | - | .. | - | .. | - | .. | 2 |
| Switzerland | .. | 5 | .. | 7 | .. | 2 | .. | - |
| Hong Kong | .. | - | .. | 3 | .. | - | .. | - |
| Subtotal | .. | 2,932 | .. | 2,766 | .. | 2,674 | .. | 2,413 |
| Total unmanufactured, sheet, ground and fabricated mica | .. | 3,953 | .. | 3,766 | .. | 3,603 | .. | 3,045 |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
Note: As figures have been rounded off, sums may not correspond to the totals indicated.
P Preliminary; nes - Not elsewhere specified; .. Not available; - Nil.

## TABLE 2. MICA CONSUMPTION IN CANADA, 1980-83

| | 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|
| | (tonnes) | | | |
| Gypsum products | 790 | 545 | 1 204 | 1 722 |
| Paint and varnish | 1 678 | 1 483 | 1 402 | 948 |
| Rubber | 24 | 54 | 30 | 52 |
| Other products[1] | 84 | 177 | 109 | 280 |
| Total | 2 576 | 2 259 | 2 745 | 3 002 |

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[1] Includes electrical apparatus, foundries, paper and paper products, floor coverings, plastics and other miscellaneous products.

## TABLE 3. WORLD PRODUCTION OF MICA, ALL VARIETIES, 1981-83

| | 1981 | 1982 | 1983 | Remarks |
|---|---|---|---|---|
| | (tonnes) | | | |
| United States[1] | 120 630 | 96 140 | 126 980 | Muscovite, flake and scrap |
| U.S.S.R.[e] | 47 160 | 48 070 | 48 980 | All varieties |
| India[e] | 29 010 | 21 540 | 19 050 | Muscovite, exports and local consumption |
| Korean Republic | 9 980 | 20 350 | 14 400 | Scrap, coproduct of kaolin and feldspath |
| Canada[2] | 12 000 | 11 000 | 12 000 | Phlogopite, flake and ground |
| France[e] | 6 800 | 6 480 | 5 990 | Muscovite, coproduct of kaolin |
| Spain | 3 520 | 3 430 | 3 400 | Muscovite, coproduct of kaolin |
| South Africa | 2 390 | 1 760 | 2 670 | Muscovite, flake |
| Brazil | 1 950 | 1 080 | 610 | Muscovite, sheet |
| Argentina | 500 | 280 | 330 | Muscovite, sheet and scrap |
| Madagascar | 380 | 280 | 330 | Phlogopite, sheet and scrap |
| Other countries | 5 300 | 2 430 | 2 540 | |
| World total[3] | 240 620 | 212 910 | 237 270 | |

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[1] Excluding the production of sericite, estimated at 35 370 tonnes in 1983. [2] Shipments estimate [3] In addition to these countries, Morocco, Taiwan and Zimbabwe produced almost 3 280 tonnes in 1981; Romania, the People's Republic of China and Pakistan are other mica producers.

[e] Estimate.

**TABLE 4. MICA[1] TRADE AND CONSUMPTION IN CANADA 1970, 1975 AND 1979-83**

| | Imports | Consumption |
|---|---|---|
| | (tonnes) | |
| 1970 | 3 422 | 2 611 |
| 1975 | 5 111 | 3 718 |
| 1979 | 3 131 | 4 498 |
| 1980 | 2 597 | 2 576 |
| 1981 | 3 133 | 2 259 |
| 1982 | 2 860 | 2 745 |
| 1983P | 2 790 | 3 002 |

Sources: Energy, Mines and Resources, Canada; Statistics Canada.
[1] Sheet and ground mica.
P Preliminary.

# Mineral Aggregates

D.H. STONEHOUSE

## SUMMARY 1983-84

Demand for mineral aggregates is created by activity in the construction industry. During 1983 and 1984 construction expenditures in Canada were about the same as in 1982 in current dollars, which means put in place construction was less than in 1982. Increased building construction in 1983, in particular in the residential sector where housing starts rose to 162,645 units from a 1982 low of only 125,860, were offset by decreased expenditures in engineering categories. Housing starts were greatly reduced through 1984 while expenditures in heavy construction rose slightly. Production of sand, gravel and crushed stone in Canada during both 1983 and 1984 was about 300 million tpy. Although the amount of mineral aggregates imported and exported is quite small, Canada is consistently a net importer of these materials.

Until recently, none of the principal lightweight aggregates (vermiculite, pumice and perlite) was mined in Canada. Imports, mainly from the United States, supplied the requirements for use in both lightweight concrete and gypsum products, for loose insulation applications and for horticulture uses. During 1983, Aurun Mines Ltd. developed a perlite property in the Empire Valley area of British Columbia and in 1984 processed approximately 1 000 t for market trials. Total imports of crude lightweight aggregate materials were greater in 1983 than in 1982 but actual production of the lightweight, expanded or exfoliated material was severely reduced as demand for these commodities in construction tapered off.

The constraints to development of aggregate properties have not lessened. Property owners do not want quarries or gravel pits nearby nor would they like to see the prices increase to compensate for greater hauling distances. An awareness of the importance of mineral aggregates to the construction industry has been heightened by an appreciation of the extent and rate of urban expansion and the realization that already large deposits of aggregate material have been made inaccessible by the growth of towns and cities or by legislation. Surveys to determine the quality and quantity of construction aggregate deposits within easy reach of many rapidly-expanding, major communities in Canada are either planned, in progress or completed. The industry has been hesitant to invest in new plant sites or major new equipment in face of the uncertain economic conditions and the uncertain impact of some new and pending legislation.

Of particular note is the development of the Ontario Government's new Planning Act and the importance given to mineral aggregates policy within the Act. Municipal plans will be required not only to protect existing pits and quarries but to identify and preserve presently untapped aggregate reserves for future development. Concern has been registered from agricultural and environmental interests that aggregates have been given greater priority than they deserve and that touted future shortages are both exaggerated and unfounded.

The fact remains that sand, gravel and stone are non-renewable resources which continue to be vital to the economy. For these reasons mineral aggregate market and resource studies have been proposed as part of mineral development programs under the Economic and Regional Development Agreements (ERDA) arranged between federal and provincial governments.

## CANADIAN DEVELOPMENTS

### Sand and Gravel

During 1983-84 production of sand and gravel averaged 225 million tpy increasing per capita consumption to over 9 tpy. Average unit values were slightly increased as well to about $2.68 a t.

Sand and gravel deposits are widespread throughout Canada, and large

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producers have established "permanent" plants as close to major consuming centres as possible. In addition to large aggregate operations usually associated with some other phase of the construction industry such as a ready-mix plant or an asphalt plant, there are many small producers serving localized markets. These are often operated on a seasonal or part-time basis. Many larger operations are short-term, intermittently serving as a supply arm of a heavy construction company, and provide material for a given project. Provincial departments of highways operate regional or divisional quarries to supply roadbed material for new and repair work. Exploitation by such a large number of widely diversified groups not only makes control difficult, it also provides great obstacles to the collection of accurate data concerning both production and consumption of sand, gravel and stone.

Estimates have indicated that available sand and gravel supplies in some regions will be depleted by the 1990s. This could make outlying deposits not only attractive but necessary to the continued operation of the Canadian construction industry in certain areas. Transportation charges represent from 35 to 58 per cent of consumer costs for over 75 per cent of sand and gravel consumption in southern Ontario, where 90 per cent is moved by truck, according to the Ontario Ministry of Natural Resources. Predicted shortages could encourage exploitation of underwater deposits and could make underground mining of crushed stone attractive.

## Crushed Stone

The large number of stone-producing operations in Canada precludes describing within this review individual plants or facilities. Many are part-time or seasonal operations, many are operated subsidiary to construction or manufacturing activities by establishments not classified to the stone industry, and some are operated directly by municipal or provincial government departments producing stone for their own direct use. Quarries removing solid rock by drilling, blasting and crushing are not likely to be operated for small, local needs as are gravel pits and are, therefore, usually operated by large companies associated with the construction industry. Depending on costs and availability, crushed stone competes with gravel and crushed gravel as an aggregate in concrete and asphalt, and as railway ballast and road metal. In these applications it is subject to the same physical and chemical testing procedures as the gravel and sand aggregates.

Detailed information about the aggregates industries can be obtained through the individual provincial departments of mines or equivalent. Most provinces have accumulated data relative to occurrences of stone of all types and in many cases have published such studies. The federal government, through the Geological Survey of Canada, has also gathered and published a great number of geological papers pertaining to stone occurrences.

## Lightweight Aggregates

Four categories generally used to classify the lightweight aggregates combine elements of source, processing methods and end-use. Natural lightweight aggregates include materials such as pumice, scoria, volcanic cinders and tuff. Manufactured lightweights are bloated or expanded products obtained by heating certain clays, shales and slates. Ultra-lightweights are made from natural mineral ores, such as perlite and vermiculite, which are expanded or exfoliated by the application of heat and used mainly as plaster aggregate or as loose insulation. Fly ash, which is obtained from the combustion of coal and coke and slag, which is obtained from metallurgical processes, are classed as byproduct aggregates.

**Perlite:** Perlite is a variety of obsidian or glassy volcanic rock that contains 2 to 6 per cent of chemically combined water. When the crushed rock is heated rapidly to a suitable temperature (760°C to 980°C) it expands to between 4 and 20 times its original volume. Expanded material can be manufactured to weigh as little as 30 to 60 kg/m$^3$, with attention being given to preblending of feed to the kiln and retention time in the kiln.

In Canada, imported perlite is expanded and used mainly by gypsum products manufacturers in plaster products such as wallboard or drywall, and in fibre-perlite roof insulation board, where its value as a lightweight material is augmented by its fire-resistant qualities. It is also used as a loose insulation and as an insulating medium in concrete products. Perlite, vermiculite, and expanded shale and clay are becoming more widely used in agriculture as soil conditioners and fertilizer carriers.

Imports of crude perlite for consumption in Canada are from New Mexico and Colorado deposits, worked by such companies as

Manville Corporation, United States Gypsum Company, United Perlite Corp. and Grefco, Inc.

Aurun Mines Ltd. has begun to produce perlite from a deposit near Empire Valley in British Columbia. During 1984 the company constructed a processing plant near Vancouver. Export markets are being investigated.

**Pumice:** Pumice is a cellular, glassy lava, the product of explosive volcanism, usually found near geologically-recent or active volcanoes. It is normally found as a loosely compacted mass composed of pieces ranging in size from large lumps to small particles. It is not the lightest of the lightweight aggregates, but when utilized as a concrete aggregate, particularly for the manufacture of concrete blocks, it exhibits strength, density and insulating values that have made it a preferred material.

In Canada, a number of concrete products manufacturers use pumice imported from Greece or from the northwestern United States, mainly in the manufacture of concrete blocks. A major use for pumice, as yet unexplored in Canada, has been in highway construction, where lightweight aggregate surfaces have been shown to have exceptional skid resistance.

Pumicite, distinguished from pumice by its finer size range (usually minus 100 mesh), is used in concretes mainly for its pozzolanic qualities. (A pozzolan is a siliceous material possessing no cementitious qualities until finely ground, in which form it will react with calcium hydroxide in the presence of moisture to form insoluble calcium silicates.)

Extensive beds of pumicite have been noted in Saskatchewan and British Columbia.

**Vermiculite:** The term vermiculite refers to a group of micaceous minerals, hydrous magnesium-aluminum silicates, that exhibit a characteristic lamellar structure and expand or exfoliate greatly upon being heated rapidly. Mining is normally by open-pit methods, and beneficiation techniques include the use of hammer mills, rod mills, classifiers, screens, dryers and cyclones. Exfoliating is done in oil- or gas-fired, vertical or inclined furnaces, usually close to the consuming facility to obviate the higher costs associated with shipping the much-bulkier expanded product. Required temperatures can vary from 1 100° C to 1 650°C depending on the type of furnace in use. A controlled time and temperature relation is critical in order to produce a product of minimum bulk density and good quality.

The expansion process has been improved technologically to enable production of various grades of expanded vermiculite as required. The uses to which the product is put depend on its low thermal conductivity, its fire-resistance and, more recently, on its lightweight qualities.

Canadian consumption is mainly as loose insulating material, with smaller amounts being used as aggregate in the manufacture of insulating plaster and concrete. The energy situation will undoubtedly result in continued increases in domestic fuel costs, and greater use of insulation in both new construction and older buildings will continue to tax the production capability of manufacturers for some time.

The major producer of vermiculite is the United States. The principal company supplying Canada's imports is W.R. Grace and Company, from operations at Libby, Montana and from the Enoree region of South Carolina. Canada also imports crude vermiculite from the Republic of South Africa, where Palabora Mining Co. Ltd. is the major producer. Minor amounts of vermiculite are produced in Argentina, Brazil, India, Kenya and Tanzania.

Vermiculite occurrences have been reported in British Columbia, and deposits near both Perth and Peterborough in Ontario have been investigated but, as yet, no commercial deposits have been developed in Canada.

**Clay, shale and slag:** Common clays and shale are used throughout Canada as raw material for the manufacture of lightweight aggregates. Although the Canadian industry began in the 1920s in Ontario, it did not evolve significantly until the 1950s when it grew in support of demands from the construction industry. The raw materials are usually quarried adjacent to the plant sites at which they are expanded. Clays receive little beneficiation other than drying before being introduced to the kiln in which they are heated. Shales are crushed and screened before burning.

In steelmaking, iron ore, coke and limestone flux are melted in a furnace. When the metallurgical process is completed, lime has combined with the silicates and aluminates of the ore and coke and formed a nonmetallic product (slag) which can be subjected to controlled cooling from the molten state to yield a porous, glassymaterial. Slag has many applications in the construction industry. The statistics relative to expanded slag production are included in those of clay and shale.

Although Canada does not produce large amounts of fly ash, the technology of fly ash processing and utilization is well advanced. The largest single use for fly ash is as a cementitious material, in which application its pozzolanic qualities are utilized. Use of fly ash as a lightweight aggregate could become increasingly important. Ontario Hydro produces over 400 000 tpy of fly ash from three coal-fired stations. Experimentation continues toward successful utilization of this material.

## PRICES

There is no standard price for sand, gravel and crushed stone. In addition to supply-demand factors, prices are determined regionally, or even locally, by production and transportation costs, by the degree of processing required for a given end use and by the quantity of material required for a particular project. Increased land values, reduction of reserves and added rehabilitation expenditures should result in higher prices.

Prices for graded, washed and crushed sand, gravel and crushed stone will show a slow but steady increase, based on greater property costs, more sophisticated operating techniques and equipment, pollution and environmental considerations, and higher labour and transportation costs.

## USES

The principal uses for sand and gravel are in highway construction and as concrete aggregate. Individual home construction triggers the need for about 300 t of aggregate per unit while apartment construction requires only about 50 t per unit, according to an Ontario Ministry of Natural Resources study.

The construction industry utilizes 95 per cent of total stone output as crushed stone mainly as an aggregate in concrete and asphalt, in highway and railway construction and as heavy riprap for facing wharves and breakwaters. Specifications vary greatly, depending on the intended use, and many tests are required to determine the acceptability of aggregates for certain applications. Particle size distribution of aggregates, as assessed by grading tests or sieve analysis, affects the uniformity and workability of a concrete mix as well as the strength of the concrete, the density and strength of an asphalt mix, and the durability, strength and stability of the compacted mass when aggregates are used as fill or base-course material. Of importance also are tests to determine the presence of organic impurities or other deleterious material, the resistance of the aggregate to abrasion and to freeze-thaw cycles, the effects of thermal expansion, absorption, porosity, reactivity with associated materials and surface texture.

The use of sand and gravel as backfill in mines continues, along with increasing use of cement and mill tailings for this purpose. Abrasive sands, glass sand, foundry sands and filter sands are also produced.

The use of lightweight concrete in commercial and institutional projects has facilitated the construction of taller building and the use of longer clear spans in bridges and buildings. Additional advantages from the use of lightweight aggregates lie in the fact that they supply thermal and acoustical insulation, fire resistance, good freeze-thaw resistance, low water absorption and a degree of toughness to the concrete product. Disadvantages stem from the fact that in production of both manufactured and ultra-lightweight aggregates heat processing is required. As the cost of fuel increases, the competitiveness of these types will be reduced unless the insulation values more than offset the heat units consumed in processing.

All types of lightweight aggregates are used in Canada, but only expanded clays, shale and slag are produced from materials of domestic origin. Vermiculite is imported mainly from Montana, although a small amount is brought in from the Republic of South Africa. Perlite is imported mainly from New Mexico and Colorado, and pumice is imported from Oregon and Greece. Most processed lightweight aggregate is utilized in the construction industry, either as loose insulating material or as aggregate in the manufacture of lightweight concrete units. The scope of such applications has not yet been fully investigated.

Any lightweight material with acceptable physical and chemical characteristics could substitute for the mineral commodities generally used. The most significant substitute for vermiculite, for instance, is styrofoam or polyurethane, which offers insulating value and comparable strength. However, these materials are petroleum-based and higher fuel prices could limit their use. Mineral wool is a competitive insulation material but its manufacture requires a pyroprocessing stage, as does the production of perlite and vermiculite. Transportation costs for high-bulk, lightweight materials are high; those materials, such as perlite and vermiculite, that can be transported to a consuming centre prior to expansion, have obvious advantages.

There are as yet no Canadian Standards Association (CSA) specifications for the lightweight aggregates. Production and application are based on the American Society for Testing and Materials (ASTM) designations as follows: ASTM Designations C 332-66 - Lightweight Aggregates for Insulating Concrete; C 330-75a - Lightweight Aggregates for Structural Concrete; and C331-69 - Lightweight Aggregates for Concrete Masonry Units.

## OUTLOOK

Urban expansion has greatly increased demand for sand and gravel in support of major construction. Paradoxically, urban spread has not only tended to overrun operating pits and quarries, but has extended at times to areas containing mineral deposits, thereby precluding the use of these resources. Further complications have arisen in recent years as society has become increasingly aware of environmental problems and the need for planned land utilization. Municipal and regional zoning must be designed to determine and regulate the optimum utilization of land, but must not be designed to provide less than optimum resources utilization. Industry must locate its plants so as to minimize any adverse effects on the environment from their operations. Also, provision must be made for rehabilitation of pit and quarry sites in order to ensure the best sequential land use. The frequency with which small quarries and pits materialize to supply short-lived, local demands, leaving unsightly properties, has prompted action by municipal and provincial governments to control or to prohibit such activity.

Ideally, the exploitation of sand, gravel and stone deposits should be done as part of the total land-use planning package, such that excavations are designed to conform with a master plan of development and even to create new land forms. Inventories indicating the potential available reserves of sand, gravel and stone should be prerequisite to legislation regulating land use. Surveys to locate such resources are being carried out in many provinces in order to optimize their use and to choose the best possible distribution routes to consuming centres. It should be observed that controls and zoning can reduce reserves of these resources significantly.

On average, total aggregate consumption will rise in line with population increases, housing requirements and construction in general. Sand and gravel consumption will continue in competition with crushed stone and, in some applications, with lightweight aggregates. New reserves must be located, assessed and made part of any community development planning or regional zoning, with optimum land and resource utilization in mind.

## TABLE 1. CANADA, TOTAL PRODUCTION OF STONE, 1982-84

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (000 t) | ($ 000) | (000 t) | ($ 000) | (000 t) | ($ 000) |
| **By province** | | | | | | |
| Newfoundland | 357 | 1,763 | 279 | 1,431 | 415 | 1,608 |
| Nova Scotia | 679 | 4,638 | 1 296 | 7,784 | 1 510 | 9,400 |
| New Brunswick | 2 261 | 11,556 | 2 087 | 11,310 | 2 005 | 10,940 |
| Quebec | 25 060 | 106,989 | 27 303 | 121,154 | 28 237 | 124,581 |
| Ontario | 23 582 | 100,278 | 27 843 | 122,272 | 29 500 | 131,335 |
| Manitoba | 2 345 | 11,670 | 1 137 | 5,452 | 1 675 | 9,300 |
| Alberta | 264 | 3,161 | 286 | 3,457 | 300 | 3,275 |
| British Columbia | 4 310 | 21,926 | 4 915 | 27,084 | 4 885 | 27,500 |
| Northwest Terrtories | 323 | 1,268 | 2 409 | 14,601 | 2 420 | 15,750 |
| Canada | 59 181 | 263,249 | 67 555 | 314,545 | 71 047 | 333,689 |
| **By use**[1] | | | | | | |
| Building stone | | | | | | |
| Rough | 230 | 4,828 | .. | .. | .. | .. |
| Monumental and ornamental stone | 38 | 4,002 | .. | .. | .. | .. |
| Other (flagstone, curbstone, paving blocks, etc.) | 26 | 1,027 | .. | .. | .. | .. |
| Chemical and metallurgical | | | | | | |
| Cement plants, foreign | 598 | 1,461 | .. | .. | .. | .. |
| Lining, open-hearth furnaces | 38 | 141 | .. | .. | .. | .. |
| Flux in iron and steel furnaces | 742 | 2,861 | .. | .. | .. | .. |
| Flux in nonferrous smelters | 114 | 1,126 | .. | .. | .. | .. |
| Glass factories | 169 | 2,271 | .. | .. | .. | .. |
| Lime kilns, foreign | 512 | 1,903 | .. | .. | .. | .. |
| Pulp and paper mills | 295 | 2,706 | .. | .. | .. | .. |
| Sugar refineries | 108 | 586 | .. | .. | .. | .. |
| Other chemical uses | 137 | 2,840 | .. | .. | .. | .. |
| Pulverized stone | | | | | | |
| Whiting (substitute) | 71 | 2,863 | .. | .. | .. | .. |
| Asphalt filler | 41 | 238 | .. | .. | .. | .. |
| Dusting, coal mines | 7 | 171 | .. | .. | .. | .. |
| Agricultural purposes and fertilizer plants | 1 037 | 10,562 | .. | .. | .. | .. |
| Other uses | 687 | 2,153 | .. | .. | .. | .. |
| Crushed stone for | | | | | | |
| Manufacture of artificial stone | 7 | 154 | .. | .. | .. | .. |
| Roofing granules | 253 | 16,776 | .. | .. | .. | .. |
| Poultry grit | 28 | 721 | .. | .. | .. | .. |
| Stucco dash | 15 | 993 | .. | .. | .. | .. |
| Terrazzo chips | 3 | 184 | .. | .. | .. | .. |
| Rock wool | - | - | .. | .. | .. | .. |
| Rubble and riprap | 1 730 | 6,421 | .. | .. | .. | .. |
| Concrete aggregate | 4 671 | 17,571 | .. | .. | .. | .. |
| Asphalt aggregate | 4 540 | 17,766 | .. | .. | .. | .. |
| Road metal | 17 997 | 62,795 | .. | .. | .. | .. |
| Railroad ballast | 2 626 | 12,823 | .. | .. | .. | .. |
| Other uses | 22 461 | 80,318 | .. | .. | .. | .. |
| Total | 59 181 | 258,261 | .. | .. | .. | .. |

P Preliminary; .. Not available; - Nil.

[1] The 1982 value of production includes companies transportation costs not applicable in the by use category.

## TABLE 2. CANADA, PRODUCTION OF SAND AND GRAVEL BY PROVINCE, 1982-84

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (000 t) | ($000) | (000 t) | ($000) | (000 t) | ($000) |
| Newfoundland | 2 839 | 9,317 | 4 057 | 18,389 | 3 715 | 16,150 |
| Prince Edward Island | 1 136 | 1,774 | 1 173 | 726 | 1 156 | 890 |
| Nova Scotia | 5 309 | 17,302 | 8 136 | 23,076 | 7 600 | 21,600 |
| New Brunswick | 6 206 | 8,359 | 5 668 | 10,830 | 5 410 | 10,275 |
| Quebec | 41 932 | 66,060 | 37 006 | 71,167 | 30 518 | 59,510 |
| Ontario | 62 256 | 156,525 | 68 316 | 174,933 | 65 300 | 166,000 |
| Manitoba | 10 284 | 28,054 | 9 909 | 26,537 | 10 950 | 27,500 |
| Saskatchewan | 8 512 | 21,001 | 7 999 | 21,014 | 9 500 | 25,500 |
| Alberta | 46 092 | 129,664 | 43 789 | 126,354 | 44 000 | 127,600 |
| British Columbia | 24 618 | 74,520 | 40 769 | 112,456 | 36 000 | 100,450 |
| Yukon and Northwest Territories | 7 088 | .. | 6 385 | 33,917 | 6 500 | 35,050 |
| Canada | 216 274 | 554,608 | 233 408 | 619,400 | 220 649 | 590,525 |

P Preliminary; .. Not available.

## TABLE 3. AVAILABLE DATA ON CONSUMPTION OF SAND AND GRAVEL, BY PROVINCE, 1981 AND 1982

| | | Atlantic Provinces | Quebec | Ontario | Western Provinces[1] | Canada |
|---|---|---|---|---|---|---|
| | | | | (000 tonnes) | | |
| Roads | 1981 | 12 631 | 34 944 | 38 110 | 47 599 | 133 284 |
| | 1982 | 11 525 | 26 430 | 36 292 | 62 441 | 136 688 |
| Concrete aggregate | 1981 | 1 018 | 4 268 | 11 688 | 10 538 | 27 512 |
| | 1982 | 1 029 | 3 037 | 9 265 | 9 106 | 22 437 |
| Asphalt aggregate | 1981 | 1 446 | 3 020 | 3 653 | 7 492 | 15 611 |
| | 1982 | 1 479 | 3 462 | 4 016 | 6 560 | 15 517 |
| Railroad ballast | 1981 | 199 | 348 | 82 | 2 299 | 2 928 |
| | 1982 | 168 | 152 | 777 | 1 699 | 2 796 |
| Mortar sand | 1981 | 18 | 409 | 1 332 | 426 | 2 185 |
| | 1982 | 37 | 307 | 865 | 354 | 1 563 |
| Backfill for mines | 1981 | 19 | 204 | 1 404 | 152 | 1 779 |
| | 1982 | 1 | 601 | 557 | 23 | 1 182 |
| Other fill | 1981 | 828 | 24 884 | 8 160 | 7 468 | 41 340 |
| | 1982 | 931 | 7 719 | 7 289 | 13 388 | 29 327 |
| Other uses | 1981 | 167 | 6 652 | 1 232 | 1 477 | 9 528 |
| | 1982 | 294 | 224 | 1 312 | 993 | 2 823 |
| Total sand and gravel | 1981 | 16 326 | 74 729 | 65 661 | 77 451 | 234 167 |
| | 1982 | 15 464 | 41 932 | 60 373 | 94 564 | 212 333 |

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[1] As of 1982 the western provinces include the Yukon and Northwest Territories.

## TABLE 4. CANADA, EXPORTS AND IMPORTS OF SAND AND GRAVEL AND CRUSHED STONE, 1981-84

| | 1981r | | 1982r | | 1983 | | Jan.-Sept. 1984 | |
|---|---|---|---|---|---|---|---|---|
| | (tonnes) | ($) | (tonnes) | ($) | (tonnes) | ($) | (tonnes) | ($) |
| **Exports** | | | | | | | | |
| Sand and gravel | | | | | | | | |
| United States | 239 641 | 649,000 | 168 179 | 624,000 | 83 931 | 328,000 | 82 475 | 418,000 |
| Bermuda | 78 888 | 262,000 | 16 | 2,000 | 11 497 | 80,000 | - | - |
| Indonesia | 5 | 25,000 | - | - | - | - | - | - |
| St. Pierre and Miquelon | 37 | 11,000 | - | - | 19 | 2,000 | 19 | 2,000 |
| France | 49 | 4,000 | 335 | 34,000 | 49 | 4,000 | 575 | 10,000 |
| Other countries | 13 | 2,000 | 162 | 25,000 | 137 | 18,000 | 274 | 47,000 |
| Total | 318 633 | 953,000 | 168 692 | 685,000 | 95 633 | 432,000 | 83 343 | 477,000 |
| Crushed limestone | | | | | | | | |
| United States | 1 758 290 | 6,007,000 | 1 516 889 | 8,475,000 | 1 390 795 | 8,375,000 | 912 248 | 5,137,000 |
| Other countries | - | - | 602 | 8,000 | - | - | 16 | 2,000 |
| Total | 1 758 290 | 6,007,000 | 1 517 491 | 8,483,000 | 1 390 795 | 8,375,000 | 912 264 | 5,139,000 |
| **Imports** | | | | | | | | |
| Sand and gravel, nes | | | | | | | | |
| United States | 1 439 686 | 6,068,000 | 1 172 707 | 5,248,000 | 878 545 | 4,362,000 | 970 784 | 4,536,000 |
| West Germany | 7 178 | 16,000 | 2 219 | 5,000 | 36 | 6,000 | 715 | 3,000 |
| Sweden | - | - | 4 341 | 10,000 | - | - | - | - |
| Other countries | - | - | 18 | 3,000 | 33 | 4,000 | 13 | 2,000 |
| Total | 1 446 864 | 6,084,000 | 1 179 285 | 5,266,000 | 878 614 | 4,372,000 | 971 512 | 4,541,000 |
| Crushed limestone | | | | | | | | |
| United States | 2 526 469 | 14,769,000 | 1 485 428 | 9,003,000 | 1 799 861 | 8,447,000 | 1 393 239 | 6,453,000 |
| Other countries | 394 | 12,000 | - | - | - | - | - | - |
| Total | 2 526 863 | 14,781,000 | 1 485 428 | 9,003,000 | 1 799 861 | 8,447,000 | 1 393 239 | 6,453,000 |
| Crushed stone, nes | | | | | | | | |
| United States | 33 108 | 1,266,000 | 71 313 | 1,239,000 | 43 889 | 1,092,000 | 37 896 | 1,034,000 |
| Sweden | 342 | 66,000 | - | - | - | - | - | - |
| Other countries | 676 | 49,000 | 67 | 5,000 | 97 | 13,000 | 285 | 28,000 |
| Total | 34 126 | 1,381,000 | 71 380 | 1,244,000 | 43 986 | 1,105,000 | 38 181 | 1,062,000 |

Source: Statistics Canada.
r Revised; - Nil; nes Not elsewhere specified.

TABLE 5. LIGHTWEIGHT AGGREGATE PLANTS IN CANADA 1983

| Company | Location | Commodity | Remarks |
|---|---|---|---|
| **Atlantic Provinces** | | | |
| Annapolis Valley Peat Moss Co. Ltd. | Berwick, N.S. | Perlite, Vermiculite | Processed mainly for use in horticulture |
| Avon Aggregates Ltd. | Minto, N.B. | Expanded Shale | Processed for concrete products industry. |
| **Quebec** | | | |
| Masonite Canada Inc. | Gatineau | Perlite | Processed for use in ceiling tile manufacture. |
| Domtar Inc. | Montreal | Perlite, Vermiculite | Processed material purchased for use in gypsum plaster and wallboard at all company plants. |
| F. Hyde & Company, Limited | Montreal | Vermiculite | Processed for use in horticulture and as loose insulation. |
| Miron Inc. | Montreal | Pumice | Purchased for concrete block manufacture. |
| Perlite Industries Inc. | Ville St. Pierre | Perlite | Processed for use in horticulture and as industrial filler. |
| V.I.L. Vermiculite Inc. | Lachine | Vermiculite | Processed for use in horticulture and as loose insulation. |
| **Ontario** | | | |
| CGC Inc. | Hagersville | Perlite | Processed for use in gypsum plaster. |
| National Slag Limited | Hamilton | Slag | Used in concrete blocks and as slag cement. |
| V.I.L. Vermiculite Inc. | Rexdale | Vermiculite | Processed for use in horticulture and as loose insulation. |
| W.R. Grace & Co. of Canada Ltd. | St. Thomas | Vermiculite | Vermiculite processed for use in horticulture and as loose insulation. |
| | Ajax | Vermiculite, Perlite | Perlite processed for use in gypsum plaster and in horticulture. |
| **Prairie Provinces** | | | |
| Apex Aggregate | Saskatoon, Sask. | Expanded clay | Processed for concrete block manufacture. |
| Cindercrete Products Limited | Regina, Sask. | Expanded clay | Processed for concrete products industry. |
| Consolidated Concrete Limited | Calgary, Alta. | Expanded shale | Processed for concrete products industry. |
| | Edmonton, Alta. | Expanded clay | Processed for concrete products industry. |
| Genstar Corporation, Edcon Block Division | Edmonton, Alta. | Expanded clay | Processed for concrete block manufacture. |
| Kildonan Concrete Products Ltd. | Winnipeg, Man. | Expanded clay | Processed for concrete products industry. |
| W.R. Grace & Co. of Canada, Ltd. | Winnipeg, Man. | Vermiculite, Perlite | Perlite processed for use in gypsum plaster and in horticulture. |
| | Edmonton, Alta. | Vermiculite, Perlite | Vermiculite processed for use in horticulture and as loose insulation. |
| **British Columbia** | | | |
| Ocean Construction Supplies Ltd. | Vancouver | Pumice | Purchased for concrete block manufacture. |

### TABLE 6. CANADA, IMPORTED RAW MATERIALS PURCHASED, 1982 AND 1983

| | 1982 | | 1983 | |
|---|---|---|---|---|
| | (tonnes) | ($) | (tonnes) | ($) |
| Pumice, perlite and vermiculite[1] | 40 617 | 5,961,961r | 47 160 | 5,267,013 |

Source: Company data.
[1] Combined to avoid disclosing confidential company data.
r Revised.

### TABLE 8. CANADA, CONSUMPTION OF SLAG, PERCENTAGE BY USE, 1981-83

| Use | 1981 | 1982 | 1983 |
|---|---|---|---|
| Concrete block manufacture | 46.0 | 38.0 | 27.0 |
| Ready-mix concrete | 2.0 | 4.0 | 2.0 |
| Loose insulation | 1.0 | 1.0 | 1.0 |
| Slag cement | 51.0 | 57.0 | 70.0 |

Source: Company data.

### TABLE 9. CANADA, CONSUMPTION OF EXPANDED CLAY AND SHALE, PERCENTAGE BY USE, 1981-83

| Use | 1981 | 1982 | 1983 |
|---|---|---|---|
| Concrete block manufacture | 76.7 | 78.7 | 80.6 |
| Precast concrete manufacture | 6.5 | 11.5 | 7.8 |
| Ready-mix concrete | 14.6 | 4.3 | 6.5 |
| Horticulture and miscellaneous uses | 2.2 | 5.5 | 5.1 |

Source: Company data.

### TABLE 10. CANADA, CONSUMPTION OF EXPANDED PERLITE, PERCENTAGE BY USE 1981-83

| Use | 1981 | 1982 | 1983 |
|---|---|---|---|
| Insulation | | | |
| in gypsum products | 11.3 | 20.6 | 21.9 |
| in other construction materials | 46.9 | 34.9 | 28.0 |
| Horticulture and agriculture | 23.9 | 33.7 | 34.6 |
| Loose insulation and miscellaneous uses | 17.9 | 10.8 | 15.5 |

Source: Company data.

### TABLE 11. CANADA, CONSUMPTION OF EXFOLIATED VERMICULITE, PERCENTAGE BY USE 1981-83

| Use | 1981 | 1982 | 1983 |
|---|---|---|---|
| Insulation | | | |
| loose | 55.2 | 45.8 | 30.2 |
| in concrete and concrete products | 8.8 | 0.5 | 0.4 |
| in gypsum products | 3.0 | 1.7 | 0.5 |
| Horticulture | 23.3 | 48.2 | 46.3 |
| Miscellaneous uses | 9.7 | 3.8 | 22.6 |

Source: Company data.

### TABLE 7. CANADA, PRODUCTION OF LIGHTWEIGHT AGGREGATES, 1982 AND 1983

| | 1982 | | 1983 | |
|---|---|---|---|---|
| | ($m^3$) | ($) | ($m^3$) | ($) |
| From domestic raw materials | | | | |
| Expanded clay, shale and slag | 260 247 | 5,832,343 | 204 264 | 5,049,810 |
| From imported crude materials | | | | |
| Expanded perlite and exfoliated vermiculite[1] | 395 540 | 12,991,301 | 216 266 | 10,796,688 |
| Total | 655 787 | 18,823,644 | 420 530 | 15,846,498 |

Source: Company data.
[1] Combined to avoid disclosing confidential company data.

TABLE 12. CANADA ROCK- MINERAL- AND GLASS-WOOL PRODUCERS, 1984

| Company | Location | Remarks |
|---|---|---|
| **Atlantic Provinces** | | |
| Fiberglas Canada Inc. | Moncton, N.B. | New in 1975. Capacity 15 000 tpy. Closed March 31, 1984. |
| **Quebec** | | |
| Fiberglas Canada Inc. | Candiac | Expanded in 1977. |
| Manville Canada Inc. | Brossard | 15 000 tpy capacity. |
| **Ontario** | | |
| Fiberglas Canada Inc. | Sarnia | Expanded in 1978. New electric furnace is largest of kind. |
| | Toronto | New plant in 1979. |
| CGC Inc. | Mount Dennis (Toronto) | Using slag from Hamilton. |
| Holmes Insulations Inc. | Sarnia | Slag - Detroit. |
| Bishop Building Materials Ltd. | Toronto | Slag - Hamilton. |
| Graham Fiber Glass Limited | Erin | New by 1979. Capacity 10 000 tpy. |
| Roxul Company | Milton | A division of Standard Industries Ltd. |
| Ottawa Fibre Industries Ltd. | Ottawa | |
| **Prairie Provinces** | | |
| Fiberglas Canada Inc. | Clover Bar, Alta. (Edmonton) | Expanded in 1977. |
| Manville Canada Inc. | Innisfail, Alta. | New in 1978. Capacity 6 000 tpm. New energy-efficient mechanical fiberizing technology in use. |
| Alberta Rockwool Corporation | Calgary, Alta. | |
| **British Columbia** | | |
| Fiberglas Canada Inc. | Mission | New in 1980. Capacity 45 000 tpy. |
| Pacific Enercon Inc. | Grand Forks | |

## TABLE 13. CANADA, VALUE OF CONSTRUCTION[1] BY PROVINCE, 1982-84

| | 1982 | | | 1983 | | | 1984 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Building Construction | Engineering Construction | Total | Building Construction | Engineering Construction | Total | Building Construction | Engineering Construction | Total |
| | | | | | ($000) | | | | |
| Newfoundland | 414,429 | 750,073 | 1,164,502 | 496,177 | 920,309 | 1,416,486 | 529,042 | 904,131 | 1,433,173 |
| Nova Scotia | 681,430 | 884,462 | 1,565,892 | 850,097 | 1,113,145 | 1,963,242 | 935,167 | 1,263,679 | 2,198,846 |
| New Brunswick | 619,611 | 462,089 | 1,081,700 | 749,843 | 414,249 | 1,164,092 | 866,945 | 503,785 | 1,370,730 |
| Prince Edward Island | 86,981 | 72,006 | 158,987 | 106,406 | 70,694 | 177,100 | 117,272 | 79,046 | 196,318 |
| Quebec | 5,547,556 | 4,672,040 | 10,219,596 | 6,693,708 | 4,388,346 | 11,082,054 | 7,183,496 | 4,352,134 | 11,535,630 |
| Ontario | 8,897,137 | 5,510,574 | 14,407,711 | 10,015,802 | 4,819,861 | 14,835,663 | 10,498,275 | 5,031,231 | 15,529,506 |
| Manitoba | 764,362 | 657,850 | 1,422,212 | 986,418 | 656,087 | 1,642,505 | 1,083,361 | 698,296 | 1,781,657 |
| Saskatchewan | 1,165,189 | 1,343,933 | 2,509,122 | 1,451,012 | 1,413,370 | 2,864,382 | 1,410,011 | 1,515,541 | 2,925,552 |
| Alberta | 6,053,165 | 8,349,406 | 14,402,571 | 4,761,621 | 7,044,529 | 11,806,150 | 3,920,440 | 7,281,719 | 11,202,159 |
| British Columbia, Yukon and Northwest Territories | 4,613,640 | 4,519,456 | 9,133,096 | 4,488,816 | 4,657,297 | 9,146,113 | 4,574,138 | 4,223,386 | 8,797,524 |
| Canada | 28,843,500 | 27,221,889 | 56,065,389 | 30,599,900 | 25,497,887 | 56,097,787 | 31,118,147 | 25,852,948 | 56,971,095 |

Source: Statistics Canada.

[1] Actual expenditures 1982, preliminary actual 1983, intentions 1984.

## TABLE 14. CANADA, VALUE OF CONSTRUCTION[1] BY TYPE, 1982-84

| | 1982 | 1983 | 1984 |
|---|---|---|---|
| | | ($ millions) | |
| **Building Construction** | | | |
| Residential | 13,581 | 16,683 | 17,240 |
| Industrial | 3,044 | 2,502 | 2,739 |
| Commercial | 7,064 | 6,228 | 5,817 |
| Institutional | 3,092 | 3,198 | 3,183 |
| Other building | 2,062 | 1,989 | 2,139 |
| Total | 28,843 | 30,600 | 31,118 |
| **Engineering Construction** | | | |
| Marine | 480 | 404 | 414 |
| Highways, airport runways | 4,310 | 4,270 | 4,328 |
| Waterworks, sewage systems | 2,244 | 2,402 | 2,391 |
| Dams, irrigation | 314 | 295 | 306 |
| Electric power | 4,866 | 4,673 | 3,827 |
| Railway, telephones | 2,390 | 2,531 | 2,811 |
| Gas and oil facilities | 9,706 | 8,115 | 9,141 |
| Other engineering | 2,912 | 2,808 | 2,635 |
| Total | 27,222 | 25,498 | 25,853 |
| Total construction | 56,065 | 56,098 | 56,971 |

Source: Statistics Canada.

[1] Actual expenditures 1982, preliminary actual 1983, intentions 1984.

# Molybdenum

D.G. FONG

## SUMMARY

Western world molybdenum production in 1984 increased by 67 per cent to 78 000 t while consumption advanced 14 per cent to 62 000 t. The supply increase was due to the resumption of operations at the major primary producers and the start-up at two new mines all located in the United States. The increase in consumption was especially significant in western Europe and the United States. However, this increase was more than offset by the expanded output, resulting in a large increase in inventories. The molybdenum market showed signs of stability following a price recovery during the early part of 1983. However, prices fell drastically during the last quarter of 1984 as a result of intense competitive selling activity by major producers.

Canada's 1984 molybdenum production, estimated at 9 070 t, remained unchanged while shipments were up eight per cent to about 10 965 t. With all three primary producers remaining on prolonged shutdown and two byproduct producers on intermittent operation, Canada's molybdenum output in 1984 represented only 38 per cent of capacity utilization.

## CANADIAN DEVELOPMENTS

Noranda Mines Inc. closed its Boss Mountain mine in British Columbia, on February 15, 1983. The mine, which had undergone a mine- and mill-expansion and was operating at 50 per cent capacity prior to the shutdown, was maintained on a standby basis. The company reopened its Gaspé, Quebec mine in September 1984 after an extended period of shutdown. The latter had been closed since June 20, 1982.

Brenda Mines Ltd., a Noranda subsidiary, reopened its Peachland, British Columbia mining operation at the end of May 1984 after an eight-month shutdown. Following a brief operation, the mine was again closed in December because of a sharp decline in metal prices and a buildup of molybdenum inventories. During the summer months of 1984, Brenda constructed additional tailing dams, channels for the diversion of runoff water, and an evaporation system to secure the area from excessive water runoff. At the end of 1983, ore reserves at Brenda were 99 million t averaging 0.148 per cent copper (Cu) and 0.032 per cent molybdenum (Mo).

Teck Corporation closed indefinitely its Highmont copper-molybdenum mine in British Columbia on October 19, 1984. Highmont's production was sold on long-term contracts, which provided for customer price support payments. Its floor price for molybdenum contained in concentrate was $US 7.50 per lb. Payments were also received as nonrecourse project loans that will be repayable out of future profits from the Highmont mine.

The Highmont mine is owned 50 per cent by Teck Corporation, 30 per cent by Redclay Holdings Limited and 20 per cent by Metallgesellschaft Canada Limited. Early in 1983, a change in mining from the West Pit to the larger East Pit resulted in an increase in copper output and a decline in molybdenum. The production of molybdenum during 1983 was 1 542 t, a reduction of 20 per cent from the previous year.

Teck also has a 21.7 per cent interest in the neighbouring Lornex Mining Corporation Ltd. However, the majority share (68.1 per cent) is held by Rio Algom Limited. Lornex operates Canada's largest porphyry copper concentrator. Production of molybdenum during 1984 estimated at 3 400 t, remained at a high level, as in 1983. The record levels of output during the past two years were due to higher tonnage throughputs and better mill head grades.

Placer Development Limited kept its Endako Mine in British Columbia closed throughout 1983 and 1984. The mine has

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been maintained on standby since its closure in June 1982. Placer was considering re-opening the mine because of declining inventories. However, no decision had been reached by the end of 1984. The company has been selling molybdenum from inventories and byproduct molybdenum production at Gibraltar mine, another of its subsidiaries in British Columbia. Placer was planning to begin production of high purity molybdenum oxide in 1985 at its Equity Silver mines near Houston, British Columbia, in addition to operating its own lubricant plant at the Endako mine site.

Amax of Canada Limited, a subsidiary of AMAX Inc. in the United States, placed the Kitsault Mine in British Columbia on an extended care and maintenance basis in July 1983 as a result of continuing weakness in the molybdenum market. Operations at Kitsault were temporarily suspended in November 1982 and it has been closed since that date. At capacity, the mine could produce 4 080 to 4 536 tpy of molybdenum.

In October 1984, Billiton Canada Ltd. reduced production by approximately 50 per cent at its Mount Pleasant tungsten-molybdenum mine. This New Brunswick mine, owned jointly by Brunswick Tin Mines Limited and Billiton, commenced commercial production at the end of 1983 and was to produce 1 600 tpy of tungsten and 350 tpy of molybdenum, both in concentrates. However, the mine had not reported any molybdenum concentrate production by the end of 1984.

## WORLD DEVELOPMENTS

Consumption in the western world declined 3 per cent in 1983 to 54 400 t of molybdenum whereas production dropped 42 per cent to 46 705 t. The sharp decline in output was due to extended mine shutdowns and production cutbacks at both the primary and byproduct producers in Canada and the United States. In 1984, however, western world production was up to an estimated 78 000 t while consumption increased to 62 000 t. Shipments to eastern bloc countries, estimated at 10 000 t, remained at about the same level as in 1983.

In the United States, the consumption of molybdenum rose 20 per cent in 1984 and demand was firm in all major market areas, especially the stainless steels. A recovery in the stainless steel industry began to improve in 1983. Also, the demand in western Europe improved significantly during 1984, especially in Sweden, West Germany and the United Kingdom. In the Japanese market, however, increases in demand for molybdenum were much more moderate.

In spite of increased consumption in 1984, the large inventory in the western world continued to increase, a setback from 1983. This inventory increase was due to the resumption of production in 1984 at the major primary producers, start-up at two new mines, and increased output at some of the byproduct producers.

AMAX Inc. of the United States restarted production at the Henderson mine in January and the Climax mine in April. Both of the AMAX mines, each with a rated capacity of 22 680 tpy of molybdenum had been closed since October 2, 1982. During 1984, both mines were operating below capacity; the Henderson mine operated two production lines and the Climax mine only one, with ores derived from underground. The open-pit at Climax remained closed due to high production costs.

Mining at Molycorp, Inc.'s Goat Hill mine began in October 1983. This new underground mine, brought on-stream at a cost of $US 250 million, is located on the same property as the Questa open-pit which was closed in 1982 due to ore exhaustion. The Goat Hill mine has a capacity to produce about 9 070 tpy of molybdenum contained in concentrate, which is roasted at the company's Washington, Pennsylvania, plant.

Amoco Minerals Company began commercial production at its Thompson Creek mine, Idaho, in early-1984. The new 25 000 tpd open-pit mine, at a cost of $US 375 million, has an annual production capacity in the range of 8 160 to 9 070 t of molybdenum, but it was operating at half capacity during the first year of operation. Thompson Creek has a reserve of 193 million t at a grade of 0.187 per cent molybdenite ($MoS_2$).

Duval Corporation operated its Sierrita, Arizona mine in 1983 at a low production rate and kept the Mineral Park and Esperanza mines idled. In late-1984, however, the company, in an effort to reduce unit production costs, raised its mining rate at Sierrita to over 100 000 tpy of ore from 85 000 tpd, and restarted the crushing plant at the Esperanza property. The increased ore output from Sierrita was hauled to Esperanza to be crushed and then returned to Sierrita for concentration.

Kennecott Minerals Company cut back production by 13 per cent at its Utah Copper mine in Bingham during the first half of 1984. In July the production rate was further reduced to one-third of capacity as a result of continued deterioration of the copper market. Molybdenum production in 1984 was reduced to about 2 087 tpy as compared with a normal level of output of 5 000 tpy.

At year end 1984, Kennecott and Anaconda Minerals Corporation signed a letter of intent to jointly run the Utah operations. Under the agreement, Kennecott would get 96 per cent of the output from its Bingham mine and the adjacent Carr Fork mine, which is owned by Anaconda. However, the arrangement must be approved by the U.S. Justice Department.

In 1983, United States Borax & Chemical Corporation continued development work at the Quartz Hill deposit near Ketchikan, Alaska. Work was completed on metallurgical tests and a 16 km access road from the mine to tidewater. The company was planning to bring the deposit into production at a rate of 54 500 tpd of ore, or about 18 000 tpy of molybdenum. However, excessive capacity world-wide prompted U.S. Borax to announce an indefinite delay in the project.

Molybdenum output from Corporation Nacional del Cobre de Chile (CODELCO) in 1984 was up 8 per cent to about 16 300 t. Production in 1983-84 was significantly lower than the record 20 000 t level CODELCO achieved in 1982. Much of CODELCO's molybdenum was derived from the Chuquicamata mine, the largest copper mine in the world. At Chuquicamata, the start-up of a molybdenum roaster in 1982 resulted in less concentrate available for toll roasting elsewhere in the western world.

## USES

Molybdenum is used in a wide range of products as an alloy additive, a chemical compound, a pure metal and as lubricants. Approximately 90 per cent of all molybdenum consumed in the western world is used in metallurgical applications including steel, cast iron, and special alloys. The remaining 10 per cent is used in non-metallurgical applications such as chemicals, catalysts and lubricants.

As a refractory additive in steel, molybdenum imparts hardenability, strength, toughness and resistance to corrosion and abrasion. Tool steels, stainless steels, high-strength steels, heat resisting steels and a wide range of alloy steels are important consumers of molybdenum. Depending on type and specification, molybdenum is added in amounts ranging from less than 0.1 per cent to nearly 10 per cent. Molybdenum can be added as a sole agent but, more often, it is used in combination with other additive metals.

Molybdenum is an important alloying element in most types of tool steels. Among the tool steel additives, molybdenum and tungsten both promote red hardness and increase wear resistance in high speed steels. The performance of these steels is proportional to the percentage of the elements. However, molybdenum produces more carbide than tungsten per unit weight added, and thus can replace tungsten at a rate of almost one to two. For some hot work tool steels and high speed steels, the molybdenum content can be as high as 9 to 10 per cent.

Additions of molybdenum to austenitic and ferritic stainless steels enhance the resistance to corrosive acids and seawater. These steels are finding increasing use in heat exchangers for severe chemical environments, seawater condenser tubings, caustic evaporators, and heat resisting steels operating under stress and high temperatures.

In high-strength, low-alloy steels, the addition of molybdenum increases the yield and tensile strength, and improves toughness and weldability. Steels with these properties are especially useful in structural applications and in Arctic-grade large-diameter pipelines. The consumption intensity of molybdenum in pipeline steels has declined, especially in Japan and western Europe where pipeline manufacturers have switched to non-molybdenum steels, even for the Arctic-grade pipelines. This increase in subtitution to other ferroalloy additives was brought about mainly by the high prices and short supply of molybdenum in the late 1970s.

Molybdenum is an important constituent of many high performance alloys that are extremely resistant to heat, corrosion and wear. These alloys are used extensively in aerospace engineering, chemical processing plants, and high temperature furnace and foundry parts.

Molybdenum compounds are used as catalysts in petroleum refining and chemical processing industries. Molybdenum orange, an important molybdenum pigment, is used in printing inks, dyes and corrosion resistant primer. Pure molybdenum disulphide is an excellent dry lubricant and is used as an oil additive. The lamellar structure of the molybdenum disulphide helps to reduce friction and thus prolongs engine life. In recent years, non-metallurgical applications have been experiencing a faster growth rate than other uses.

## PRICES

Molybdenum prices on the spot market improved from $US 5.40 a kg of oxide at the begining of 1983 to a high of $US 7.94-9.81 at the end of the first quarter. The sharp price increase was mainly due to a scarcity of molybdenum concentrates in the spot market. Meanwhile, North American producers raised their prices on oxide to $US 11.02 a kg. Subsequently, prices began to weaken and producer prices for oxide at the end of the year were being quoted at $US 9.26-9.81 while the spot price declined to $US 8.27-8.93 a kg.

By year-end 1983, major molybdenum producers including AMAX and Placer Development discontinued publication of producer list prices. Accordingly, the dealer price became the only published reference price in the molybdenum market.

The molybdenum market showed signs of stability during the first three quarters of 1984. Dealer prices for oxide hovered around the $US 8.05-8.93 level. However, prices dropped abruptly during the last quarter of 1984, apparently sparked by rumours of distress sales of molybdenum by the major producers. At year-end, the price of oxide in the dealer market was quoted at $US 6.17-6.72 a kg.

## OUTLOOK

The demand for molybdenum will continue to rely on steel production intensity, especially in the alloy, stainless and tool steels sector which together account for about 75 per cent of total molybdenum consumption. Although consumption improved substantially in 1984 as a result of the economic recovery, it is unlikely that demand will return to the record level of the 1970s before the second half of the 1990s.

The consumption of molybdenum is forecast to increase by 7 or 8 per cent in 1985 and slow to 2 to 3 per cent in 1986. However, a significant increase in interest rates would have a dampening impact on the economic recovery, and hence, the growth rate of molybdenum demand.

Among the end uses, growth is projected for the transportation sector where fuel efficiency and weight reduction considerations will result in a rising consumption of high strength steels. The oil and gas industries, which are expanding their use of stainless steels will also provide a major growth market for molybdenum.

The superalloy and electronics sectors have fully recovered from the economic downturn and are showing signs of strong growth, especially in military, aerospace and high technology applications. Also, the capital goods market is recovering steadily after a very poor performance during the recessionary years.

At the 1984 rate of production, western world producer inventories are expected to increase by 9 070 t in 1985 to about 79 000 t. The excess supply, mainly due to the large increase in output in the United States, will result in a continuing market weakness and could lead to production cuts in 1986. In the long run, production restraint will be an ongoing industry challenge if market stability is to be achieved.

Despite the weak molybdenum market in recent years, the average growth rate for consumption during the next two decade is expected to be comparable with that of the past decade, due in large part to the increasing use of molybdenum in low-alloy steels. A stable and dependable supply of molybdenum at relatively low prices will favor the expanding use of molydenum as compared with many of its substitutes.

Despite the rapid growth of steel production in the developing countries and a continuing decline in steel output in the advanced industrial nations, a major shift of molybdenum consumption to the developing countries is not expected to take place in the next two decades. This is because the specialized technology for making alloy steel is concentrated in the advanced industrial countries; most of the steel production in developing countries will continue to be common carbon steels.

World production capacity for molybdenum is more than adequate to satisfy the projected demand increase well into the next decade. Also, new copper developments that will give rise to byproduct molybdenum and mine expansions in Chile and Peru will result in additional supplies of molybdenum in years to come. Moreover, there are a number of well defined molybdenum deposits, especially in North America, which could be developed when the world's supply and demand approach a reasonable balance.

## PRICES

Prices in $US per kilogram of contained molybdenum, fob shipping point unless indicated otherwise, December 31.

| | 1983 | 1984 |
|---|---|---|
| | ($) | |
| Byproduct concentrates ($MoS_2$) | 7.28-7.94 | 5.95-6.39 |
| Export oxide ($MoO_3$) in cans | 8.65-13.23 | 8.65-13.23 |
| Dealer oxide ($MoO_3$) in cans; min. 57% Mo | 8.27-8.93 | 6.06-6.61 |
| Ferromolybdenum[1] | | |
| Dealer export (fas port) | 9.81-10.03 | 7.83-8.05 |

Source: Metals Week.

[1] Price based on molybdenum content.

fob Free on board, fas Free alongside ship.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| CANADA | | | | | |
| 32900-1 | Molybdenum ores and concentrates | free | free | free | free |
| 33505-1 | Molybdenum oxides | 10.0 | 13.8 | 25.0 | 9.0 |
| 37506-1 | Ferromolybdenum | free | 4.7 | 5.0 | free |
| 35120-1 | Molybdenum metal in powder, pellets, scrap, ingots, sheets, strips, plates, bars, rods, tubing or wire, for use in Canadian manufactures | free | free | 25.0 | free |
| 92847-1 | Molybdates | 10.0 | 12.1 | 25.0 | 8.0 |
| | Temporary reduction, June 3, 1980 to June 30, 1987 | free | | | free |
| 92856-1 | Molybdenum carbides | 9.4 | 7.5 | 25.0 | 5.0 |
| | Temporary reduction, June 3, 1980 to December 31, 1986 | free | | | free |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 33505-1 | 13.8 | 13.4 | 13.1 | 12.8 | 12.5 |
| 37506-1 | 4.7 | 4.5 | 4.3 | 4.2 | 4.0 |
| 92847-1 | 12.1 | 11.4 | 10.7 | 9.9 | 9.2 |
| 92856-1 | 7.5 | 5.6 | 3.8 | 1.9 | free |

**TARIFFS** (cont'd)

UNITED STATES

| | | | | | | |
|---|---|---|---|---|---|---|
| 601.33 | Molybdenum ore (per lb on Mo content) | 10.5¢ | 10.1¢ | 9.8¢ | 9.4¢ | 9.0¢ |
| 419.60 | Molybdenum compounds | 3.7 | 3.5 | 3.4 | 3.3 | 3.2 |
| 606.31 | Ferromolybdenum | 5.9 | 5.6 | 5.2 | 4.9 | 4.5 |
| 628.70 | Molybdenum metal, waste and scrap | 8.3 | 7.7 | 7.1 | 6.6 | 6.0 |
| 628.72 | Molybdenum metal, unwrought | 8.1¢/ lb on Mo content +2.5 | 7.6¢/ lb on Mo content +2.3 | 7.2¢/ lb on Mo content +2.2 | 6.7¢/ lb on Mo content +2.0 | 6.3¢/ lb on Mo content +1.9 |
| 628.74 | Molybdenum metal, wrought | 9.6 | 8.8 | 8.1 | 7.3 | 6.6 |
| 417.28 | Ammonium molybdate | 5.3 | 5.0 | 4.8 | 4.5 | 4.3 |
| 418.26 | Calcium molybdate | 4.8 | 4.8 | 4.8 | 4.7 | 4.7 |
| 421.10 | Sodium molybdate | 4.4 | 4.2 | 4.1 | 3.9 | 3.7 |
| 423.88 | Molybdenum carbide | 3.2 | 3.1 | 3.0 | 2.9 | 2.8 |

| EUROPEAN ECONOMIC COMMUNITY (MFN) | | 1983 | Base Rate (%) | Concession Rate |
|---|---|---|---|---|
| 26.01 | Molybdenum ores and conc | free | | |
| 28.28 | Molybdenum oxides and hydroxides | 6.7 | 8.0 | 5.3 |
| 73.02 | Ferromolybdenum | 6.3 | 7.0 | 4.9 |
| 81.02 | Molybdenum metal | | | |
| | A. Unwrought: powder | 6 | | |
| | other | 5 | | |
| | B. Wrought: bars, angles, plates, sheets, strip, wire | 8 | | |
| | C. Other | 10 | | |
| 28.47 | Molybdates | 8.9 | 11.2 | 6.6 |
| 28.56 | Molybdenum carbides | 8.6 | 9.6 | 8.0 |

JAPAN (MFN)

| | | | | |
|---|---|---|---|---|
| 26.01 | Molybdenum ores and conc | | | |
| | A. Quota | free | | |
| | B. Other | 3.8 | 7.5 | free |
| 28.28 | Molybdenum trioxide | 3.8 | 5.0 | 3.7 |
| 73.02 | Ferromolybdenum | 5.3 | 7.5 | 4.9 |
| 81.02 | Molybdenum metal | | | |
| | A. Unwrought, powders and flakes | 3.8 | 5.0 | 3.7 |
| | B. Waste and scrap | 3.8 | 5.0 | 3.7 |
| | C. Other | 5.3 | 7.5 | 4.9 |
| 28.47 | Molybdates | 5.3 | 7.5 | 4.9 |
| 28.56 | Molybdenum carbides | 3.8 | 5.0 | 3.7 |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated 1983, USITC publication 1317; U.S. Federal Register, Vol. 44, No. 241; Official Journal of the European Communities, Vol. 25, No. L318, 1982; Customs Tariff Schedules of Japan, 1983.

TABLE 1. CANADA, MOLYBDENUM PRODUCTION AND TRADE, 1982-84, AND CONSUMPTION, 1982-83

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Production** (shipments)[1] | | | | | | |
| British Columbia | 13 584 | 155,112 | 10 179 | 87,564 | 10 865 | 108,916 |
| Quebec | 377 | 4,030 | 15 | 146 | 100 | 1,060 |
| Total | 13 961 | 159,142 | 10 194 | 87,710 | 10 965 | 109,976 |
| **Exports** | | | | | (Jan.-Sept.) | |
| Molybdenum in ores, concentrates and scrap[2] | | | | | | |
| United Kingdom | 1 574 | 21,215 | 2 452 | 24,374 | 719 | 6,783 |
| Belgium-Luxembourg | 3 000 | 48,578 | 1 969 | 22,216 | 834 | 7,465 |
| Netherlands | 3 344 | 43,104 | 2 097 | 19,511 | 969 | 9,173 |
| West Germany | 2 314 | 23,207 | 2 006 | 16,404 | 1 173 | 10,273 |
| Japan | 3 185 | 53,492 | 1 274 | 14,940 | 1 947 | 22,954 |
| United States | 2 249 | 31,341 | 437 | 3,584 | 244 | 2,241 |
| Austria | 393 | 1,036 | 404 | 2,900 | .. | .. |
| Chile | 468 | 3,928 | 517 | 2,422 | 396 | 3,651 |
| Other countries | 916 | 12,217 | 128 | 1,426 | 94 | 853 |
| Total | 17 443 | 238,118 | 11 284 | 107,777 | 6 349 | 63,393 |
| **Imports** | | | | | | |
| Molybdic oxide (containing less than 1 per cent impurities) | 193 | 2,740 | 141 | 1,486 | 209 | 2,165 |
| Molybdenum in ores and concentrates (Mo content) | 3 027 | 40,119 | 233 | 1,833 | ..<br>162 | ..<br>1,873 |
| Ferromolybdenum alloys | 77 | 1,017 | 34 | 323 | | |

| | 1982 | | 1983 | |
|---|---|---|---|---|
| | (kilograms) | ($) | (kilograms) | ($) |
| **Consumption** (Mo content) | | | | |
| Addition agents | 512 553 | .. | 387 874 | .. |
| Electrical and electronics | 4 960 | .. | 2 009 | .. |
| Other Uses[3] | 153 855 | .. | 100 234 | .. |
| Total | 671 368 | .. | 490 117 | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments (Mo content of molybdenum concentrates, molybdic oxide and ferromolybdenum). [2] Includes molybdenite and molybdic oxide in ores and concentrates. [3] Alloy, pigment and ceramics.
P Preliminary; .. Not available.

### TABLE 2. CANADA, MOLYBDENUM PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975 AND 1979-84

|  |  |  | Imports |  |  |
|---|---|---|---|---|---|
|  | Production[1] | Exports[2] | Molybdic oxide[3] | Ferro-molybdenum[4] | Consumption[5] |
|  |  |  | (kilograms) |  |  |
| 1970 | 15 318 593 | 13 763 800 | 33 500 | 29 619 | 1 036 940 |
| 1975 | 13 323 144 | 15 710 300 | 56 400 | 269 281 | 1 436 883 |
| 1977 | 16 567 555 | 15 326 100 | 192 100 | 74 330 | 1 149 736 |
| 1978 | 13 943 405 | 13 421 000 | 329 500 | 55 294 | 1 268 640 |
| 1979 | 11 174 586 | 11 481 900 | 335 900 | 153 945 | 1 249 944 |
| 1980 | 11 889 000 | 14 584 500 | 361 700 | 53 618 | 1 055 107r |
| 1981 | 12 850 000 | 13 664 000 | 423 000 | 36 069 | 1 311 863 |
| 1982 | 13 961 000 | 17 444 000 | 193 000 | 6 840 | 671 368 |
| 1983 | 10 194 000 | 11 284 000 | 141 000 | 34 000 | 490 117 |
| 1984P | 10 965 000 | 8 465 000 | 313 000 | 243 000 | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada; except where noted.
[1] Producers' shipments (Mo content of molybdenum concentrates, oxide and ferromolybdenum). [2] Mo content, ores and concentrates. [3] Gross weight. [4] United States exports to Canada, reported by the U.S. Bureau of Commerce, Exports of Domestic and Foreign Merchandise (Report 410), over 50 per cent molybdenum. [5] Mo content of molybdenum products reported by consumers.
P Preliminary for production and estimate for trade data; .. Not available; r Revised.

TABLE 3. CANADA, MINE PRODUCTION, 1983

| Company and Mine Name | Location | Type of Producer | Mill Capacity (tpd) | Ore Milled | | Concentrates Produced | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Tonnes | Grade (% Mo) | Tonnes | Grade (% Mo) | Contained Mo (tonnes) |
| Amax of Canada Limited Kitsault Mine | Alice Arm B.C. | Primary | 10 886 | - | - | - | - | - |
| Brenda Mines Ltd. | Peachland, B.C. | Coproduct | 27 200 | 8 185 403 | 0.032 | 3 629 | 55.52 | 2 015 |
| Gibraltar Mines Limited | McLeese Lake, B.C. | Byproduct | 37 195 | 13 437 210 | 0.010 | 797 | 54.57 | 435 |
| Highmont Mining Corporation | Highland Valley, B.C. | Coproduct | 22 680 | 8 799 692 | 0.024 | 2 910 | 53.75 | 1 674 |
| Lornex Mining Corporation Ltd., | Highland Valley, B.C. | Byproduct | 72 575 | 28 766 769 | 0.016 | 6 351 | 53.23 | 3 381 |
| Noranda Mines Limited, Boss Mountain Division | Williams Lake, B.C. | Primary | 2 631 | 29 772 | 0.187 | 93 | 54.98 | 51 |
| Mines Gaspé Division Needle Mountain and Copper Mountain | Holland Twp. Gaspé, Que. | Byproduct | 32 800 | - | - | - | - | - |
| Placer Development Limited, Endako Mine | Endako, B.C. | Primary | 29 937 | - | - | - | - | - |
| Utah Mines Ltd., Island Copper mine | Port Hardy, B.C. | Byproduct | 38 100 | 16 330 081 | 0.017 | 3 426 | 46.65 | 1 599 |
| Total | | | | | | | | 9 155 |

Sources: Energy, Mines and Resources Canada; Company annual reports.
- Nil.

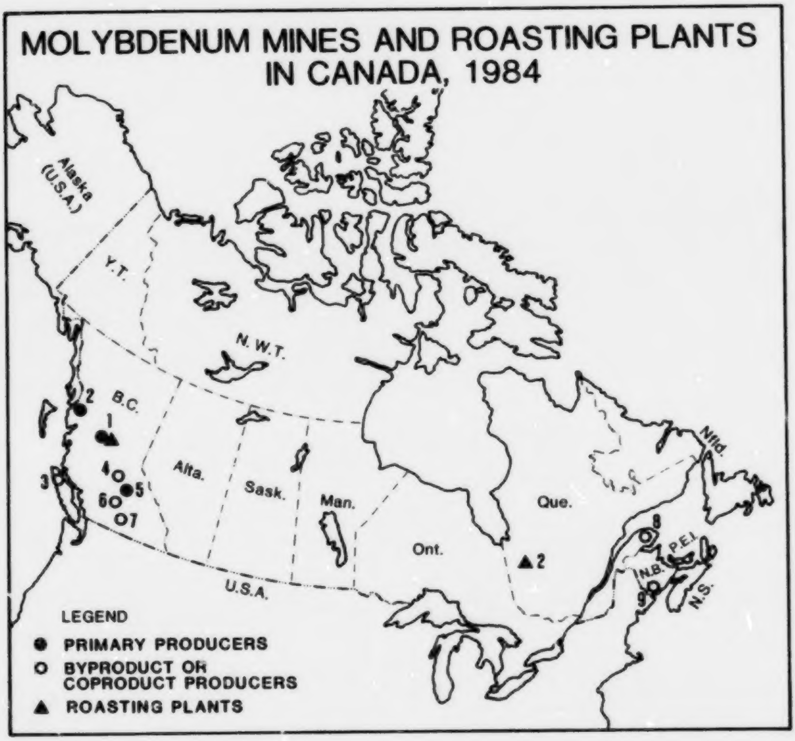
### TABLE 4. WORLD PRODUCTION OF MOLYBDENUM IN ORES AND CONCENTRATES, 1981-83

| Country | 1981 | 1982P | 1983e |
|---|---|---|---|
| | (tonnes Mo content) | | |
| United States | 63 458 | 37 671 | 13 608 |
| Canada | 12 850 | 13 961 | 10 523 |
| Chile | 15 360 | 20 000 | 14 515 |
| U.S.S.R.e | 10 705 | 11 022 | .. |
| People's Republic of Chinae | 1 996 | 1 996 | .. |
| Peru | 2 488 | 2 565 | 2 722 |
| Republic of Korea | 465 | 400 | .. |
| Bulgariae | 150 | 150 | .. |
| Japane | 74 | 98 | .. |
| Philippines | 80 | 60 | .. |
| Mexico | 451 | 450 | .. |
| Mongolia | .. | .. | 14 515 |
| Total | 108 077 | 88 373 | 55 883 |

Sources: Energy, Mines and Resources Canada; U.S. Bureau of Mines, Minerals Yearbook, Preprint, 1982; U.S. Bureau of Mines, Mineral Commodity Summaries, 1984.
P Preliminary; e Estimated; .. Not available.

### TABLE 5. PRINCIPAL MOLYBDENUM PRODUCERS IN THE WESTERN WORLD, 1984

| Company | Country | Installed Capacity (000 tpy Mo) |
|---|---|---|
| AMAX Inc. | United States | 45 |
| Corporacion Nacional del Cobre de Chile (CODELCO-Chile) | Chile | 20 |
| Duval Corporation | United States | 10 |
| Amoco Minerals Company | United States | 9 |
| Molycorp, Inc. | United States | 9 |
| Placer Development Limited | Canada | 7.7 |
| Anaconda Minerals Corporation | United States | 6.8 |
| Mexicana de Cobre, S.A. | Mexico | 5.4 |
| Kennecott Minerals Company | United States | 5 |
| Noranda Inc. | Canada | 4.5 |
| Southern Peru Copper Corporation | Peru | 4.5 |
| Amax of Canada Limited | Canada | 4 |
| Lornex Mining Corporation Ltd. | Canada | 3.6 |
| Newmont Mining Corporation | United States | 2.2 |
| Teck Corporation | Canada | 2.0 |
| Utah Mines Ltd. | Canada | 1.6 |
| Others | | 4.5 |
| Total | | 144.8 |



MOLYBDENUM MINES AND ROASTING PLANTS IN CANADA, 1984

Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
1
2
3
4
5
6
7
8
9
2
LEGEND
● PRIMARY PRODUCERS
○ BYPRODUCT OR COPRODUCT PRODUCERS
▲ ROASTING PLANTS

**Mines**

1. Placer Development Limited (Endako mine)
2. Amax of Canada Limited (Kitsault mines)
3. Utah Mines Ltd. (Island Copper mine)
4. Gibraltar Mines Limited
5. Noranda Inc. (Boss Mountain Division)
6. Lornex Mining Corporation Ltd.
   Highmont Mining Corporation
7. Brenda Mines Ltd.
8. Noranda Inc. (Gaspé Division)
9. Mount Pleasant Mines Limited

**Roasting Plants**

1. Placer Development Limited (Endako mine)
2. Eldorado Gold Mines Inc. (Duparquet)

# Nepheline Syenite and Feldspar

MICHEL A. BOUCHER

## SUMMARY

Nepheline syenite is produced commercially as an industrial raw material for the manufacture of glass and ceramics, mainly by Canada and Norway, and to a smaller extent by Brazil and the U.S.S.R. However, only Canada and Norway export nepheline syenite in large quantities. The producers in these countries have very defined markets with Canada exporting mainly to the United States and Norway exporting mainly to western Europe.

In 1983 and 1984, Canadian production and exports continued to decrease from the high level reached in 1979. The decline in production was due mainly to lower demand for container glass, which must compete with plastics and aluminum, and to an increase in glass waste recycling. Lower exports were the result of the closing of glass plants in the United States in recent years, the acceptance of lower quality feldspathic material by United States manufacturers, and recent deregulation of transport in the United States that makes producers of aplite and feldspar (which are substitutes for nepheline syenite in glass production) in the United States more competitive with Canadian nepheline syenite.

Prices remained stable in 1983 and 1984.

## CANADIAN DEVELOPMENTS

### Production

Nepheline syenite is produced in Ontario by two companies - Indusmin Limited, a subsidiary of Falconbridge Nickel Mines Limited and IMC Industry Group (Canada) Ltd. a subsidiary of International Minerals & Chemical Corporation (IMC). The two companies have an estimated combined production capacity of 800 000 tonnes (t) of finished product a year, with Indusmin being the largest producer. Nepheline syenite is mined by these companies from two adjacent deposits located on Blue Mountain in Methuen Township, Peterborough County, 175 km northeast of Toronto. Operating capacity at the two plants was between 60 and 65 per cent in 1983 and 1984, and no major capital expenditures were reported at either operation during those years. The nepheline syenite is upgraded to low-iron and high-iron glass grades, and to ceramic grades by primary and secondary crushing, drying, screening, high-intensity magnetic separation, pebble milling, and for ultra-fine grades (for use as filler in paints, plastics, etc.) using fluid energy mills and air classification.

Feldspar was not produced in Canada in 1983 nor in 1984.

## CONSUMPTION

The glass and glass fibre industries account for some 70 per cent of nepheline syenite consumption in Canada. As stronger growth is expected in the future in filler and extender pigment applications (plastics, paints, etc.) than in the glass industry further diversification by the producers into these markets is expected. It may take years, however, before substantial tonnages in these applications can be attained. Producers will have to attempt to demonstrate the special properties of nepheline syenite over readily available and excellent materials such as kaolin, calcium carbonate, etc.

Consumption of nepheline syenite in Canada by glass producers continued to be influenced by the use of plastics and aluminum, by increased recycling of glass waste, and by the development of thinner glass containers.

The major consumers of nepheline syenite in Canada are Dominion Glass Company Limited, Consumers Glass Company Limited, Fiberglass Canada Limited, American Standard Incorporated, and Crane Canada Inc.

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## TRADE

Canada has a large trade surplus in nepheline syenite and feldspar with the United States. While exports of nepheline syenite to the United States average about 350 000 tpy, imports of feldspar from the United States average about 4 000 tpy. Nearly all feldspar imported into Canada comes from North Carolina where both Indusmin and IMC have mining operations.

## PRICES

The value of production per t increased by 10 per cent in 1983 and 5 per cent in 1984. However, the value of exports per t increased by only 7.7 per cent in 1983 and 3.3 per cent in 1984 (based on 9 month figures), barely offsetting inflation.

Prices for nepheline syenite in 1984 ranged from a low of $22 per t for sand, to a high of $93 per t for filler and extender grade. Listed prices for nepheline syenite products have remained the same since 1982 while feldspar prices were only increased in 1984.

## USES

Nepheline syenite is preferred to feldspar as a source of alumina and alkalis for glass manufacture. Its use results in more rapid melting of the batch at lower temperatures than with feldspar thus reducing fuel consumption, lengthening the life of furnace refractories, and improving the yield and quality of glass. Other industrial uses for nepheline syenite include ceramic glazes, enamels, fiberglass and fillers in paints, papers, plastics and foam rubber.

Feldspar is the name of a group of minerals consisting of aluminum silicates of potassium, sodium and calcium. It is used in glassmaking as a source of alumina and alkalis, in ceramic bodies and glazes, in cleaning compounds as a moderate abrasive and as a flux coating on welding rods. High calcium feldspars, such as labradorite, and feldspar-rich rocks, such as anorthosite, find limited use as building stones and for other decorative purposes. Potash feldspar is an essential ingredient in the manufacture of high voltage porcelain insulators. Dental spar, which is used in the manufacture of artificial teeth, is a pure white potash feldspar, free of iron and mica.

## OUTLOOK

Only a modest increase in sales of nepheline syenite can be expected in 1985. This is mainly due to improvements in the ceramic and fiberglass markets.

In the medium-term, if the North American economy does not improve, some small producers of feldspar in eastern United States can be expected to close.

In the longer-term glass container producers will continue to compete with plastics and aluminum producers. Fiberglass is bulky and consequently expensive to transport and may over the years loose markets to more compact material, consequently slow growth can be expected in this area. The use of nepheline syenite in ceramics and as a filler is expected to grow substantially, but consumption tonnages will remain small for several years compared with tonnages used in glass and fiberglass.

There are opportunities for new feldspar or nepheline syenite development in western Canada as all the production currently is concentrated in eastern Canada and eastern United States.

## PRICES OF FELDSPAR AND NEPHELINE SYENITE IN U.S. CURRENCY

| | 1983 | 1984 |
|---|---|---|
| | ($/tonne) | |
| **FELDSPAR** | | |
| Ceramic grade, bulk | | |
| FOB Spruce Pine, NC, 170-250 mesh | 45.46 | 48.50 |
| FOB Monticello, Ga, 200 mesh, high potash | 76.31 | 81.00 |
| FOB Middleton, Con, -200 mesh | 55.65 | 58.68 |
| Glass grade, bulk | | |
| FOB Spruce Pine, NC, 97.8% + 200 mesh | 30.30 | 32.34 |
| FOB Middleton, Con, 96% + 200 mesh | 41.05 | 42.98 |
| FOB Monticello, Ga, 200 mesh, high potash | 56.20 | 59.50 |
| **NEPHELINE SYENITE** | | |
| Canadian, CL-car lots TL-truck lots | | |
| Glass gr., 30 mesh, bulk CL/TL, low iron | 28.65-31.40 | 28.65-31.40 |
| Glass gr., 30 mesh, bulk CL/TL, high iron | 22.04-25.62 | 22.04-25.62 |
| Ceramic gr., 200 mesh, bagged 10-ton lots | 60.60-62.81 | 60.60-62.81 |
| Filler/extender grade | 73.83-93.67 | 73.83-93.67 |

Source: Industrial Minerals, December 1983 and December 1984.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | (%) | (%) | (%) | (%) |
| CANADA | | | | | |
| 29600-1 | Feldspar, crude | free | free | free | free |
| 29625-1 | Feldspar, ground but not further manufactured | free | 6.5 | 30 | free |
| 29640-1 | Ground feldspar for use in Canadian manufactures | free | free | 30 | free |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 29625-1 | 6.5 | 6.3 | 6.0 | 5.8 | 5.5 |

UNITED STATES (MFN)

| | | |
|---|---|---|
| 522.31 | Crude feldspar | free |

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 522.41 | Feldspar, crushed, ground or pulverized | 3.2 | 3.1 | 3.0 | 2.9 | 2.8 |

Sources: The Customs Tariff, 1983 Revenue Canada Customs and Excise; Tariff Schedules of the United States, Annotated 1983, USITC Publication 1317. U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, NEPHELINE SYENITE PRODUCTION, EXPORTS AND CONSUMPTION, 1982-84

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($) | (tonnes) | ($) | (tonnes) | ($) |
| **Production** (shipments) | 550 480 | 17,323,776 | 523 249 | 18,130,692 | 485 012 | 17,671,351 |
| | | | | | (Jan.-Sept. 1984) | |
| **Exports** | | | | | | |
| United States | 373 932 | 13,557,000 | 345 245 | 13,469,000 | 259 637 | 10,514,000 |
| Netherlands | 24 490 | 1,014,000 | 20 995 | 1,019,000 | 14 094 | 630,000 |
| Italy | 6 834 | 495,000 | 8 614 | 658,000 | 4 766 | 378,000 |
| United Kingdom | 4 751 | 256,000 | 8 926 | 472,000 | 295 | 34,000 |
| Australia | 1 537 | 121,000 | 8 943 | 294,000 | 1 241 | 95,000 |
| Spain | 269 | 18,000 | 1 927 | 105,000 | 679 | 49,000 |
| Other countries | 2 975 | 304,000 | 3 649 | 293,000 | 3 161 | 308,000 |
| Total | 414 788 | 15,765,000 | 398 299 | 16,310,000 | 283 873 | 12,008,000 |
| **Consumption**[1] | | | | | | |
| Glass and glass fibre | 75 852 | | | | | |
| Insulation | 10 898 | | | | | |
| Ceramic products | 10 465 | | | | | |
| Paints | 3 669 | | | | | |
| Others[2] | 1 725 | | | | | |
| Total | 102 609 | .. | .. | .. | | |

Sources: Statistics Canada; Energy, Mines and Resources, Canada.
[1] Available data, as reported by consumers. [2] Includes frits and enamel, foundry, plastics, rubber products, electrical apparatus and other minor uses.
P Preliminary; .. Not available.

### TABLE 2. CANADA, NEPHELINE SYENITE PRODUCTION AND EXPORTS, 1970, 1975 AND 1979-83

| | Production[1] | Exports |
|---|---|---|
| | (tonnes) | |
| 1970 | 454 110 | 351 940 |
| 1975 | 468 427 | 356 629 |
| 1979 | 605 699 | 471 056 |
| 1980 | 600 000 | 448 468 |
| 1981 | 588 000 | 476 281 |
| 1982 | 550 480 | 414 788 |
| 1983 | 5[illegible]3 249 | 398 299 |

Sources: Energy, Mines and Resources, Canada; Statistics Canada.

[1] Producers' shipments.

### TABLE 3. CANADA, ESTIMATED FELDSPAR CONSUMPTION, 1981 AND 1982

| | 1981 | 1982 |
|---|---|---|
| | (tonnes) | |
| Consumption | | |
| Whiteware | 4 410 | 2 585 |
| Other products[1] | 196 | 205 |
| Total | 4 606 | 2 790 |

[1] Includes porcelain enamel, artificial abrasives and other minor uses.

### TABLE 4. CANADA, IMPORTS AND CONSUMPTION OF CRUDE OR GROUND FELDSPAR, 1975 AND 1979-83

| | Imports | Consumption |
|---|---|---|
| | ($) | (tonnes) |
| 1975 | .. | 5 630 |
| 1979 | 501,000 | 4 588 |
| 1980 | 385,000 | 4 051 |
| 1981 | 642,000 | 4 606 |
| 1982 | 251,000 | 2 790 |
| 1983 | 309,000 | .. |

Sources: Statistics Canada; Energy, Mines and Resources Canada.

.. Not available.

### TABLE 5. WORLD PRODUCTION OF FELDSPAR, 1982 AND 1983

| | 1982 | 1983$^e$ |
|---|---|---|
| | (tonnes) | |
| United States | 557 919 | 625 957 |
| Italy | 399 161 | 399 161 |
| West Germany | 340 194 | 344 730 |
| France | 181 437 | 190 509 |
| Mexico | 117 934 | 127 006 |
| Spain | 99 790 | 108 862 |
| Brazil | 95 254 | 99 790 |
| Other countries | 1 307 254 | 1 324 491 |
| Total | 3 098 943 | 3 220 506 |

Source: United States Bureau of Mines Mineral Commodity Summaries, 1984.

$^e$ Estimated.

# Nickel

R.G. TELEWIAK

Strong growth in the United States economy was the principal factor in nickel consumption in the western world increasing by an estimated 12 per cent in 1984, compared to 1983. This was the second consecutive year of growth in consumption and brought the level to an estimated 560 000 t, which was slightly below the record high reached in 1979.

Growth in the consumer goods sector was the leading factor in nickel demand trends in 1983 but, with economic recovery shifting into a more mature phase, demand from the capital sector was more important in 1984. Unlike other economic recoveries, however, nickel demand from the capital sector tended to reflect modernization of existing plants, as opposed to major new plant construction and expansion.

Producers around the world carried out extensive cost-saving programs in 1983 and 1984. The nickel price on the London Metal Exchange (LME) averaged $US 2.12 in 1983 and $2.16 in 1984, compared to $2.70 in 1981; and this low price and the expectation that the price will continue to be under pressure for several years, due to global overcapacity, forced producers to take dramatic measures to reduce costs. While some of the measures, such as selective mining, are short-term, many others will result in long-term cost-savings due to improved mining and processing techniques and equipment.

## CANADIAN DEVELOPMENTS

Inco Limited and Falconbridge Limited both substantially reduced production costs and by late-1984, Inco announced that the break-even price for its nickel operations was $US 2.20 and Falconbridge announced that its costs were marginally below $2.00. By comparison, Falconbridge stated its costs were $3.40 in 1981; no estimate is available for Inco. Costs in all segments of the operations were reduced, as evidenced by 3.8 per cent decrease in mining costs from 1981 to 1984 to $Cdn 28.00 per t announced by Inco.

In June 1984, a series of rockbursts occurred at the Falconbridge and East mines of Falconbridge at Sudbury. Four fatalities resulted and the Falconbridge mine, after 55 years of operation, was permanently closed. Production subsequently resumed at the East mine and the adjacent Falconbridge shaft and certain haulage areas, were made safe for the hoisting of ore from this mine.

Inco resumed production at Sudbury, Port Colborne and Shebandowan in April 1983 after a nine month shutdown brought on by low prices and high inventories. Four-week summer closures were taken in 1983 and 1984. Faced with excess refining capacity, Inco decided to indefinitely suspend electrolytic production at Port Colborne. Utility nickel will still be produced.

Development work commenced in September 1983 on Inco's Thompson open-pit in Manitoba, with production scheduled to begin early in 1986. The Pipe open-pit was mined out in 1984 but with some ore stockpiled from this pit, along with some ore from the Thompson underground mine, there will adequate feed to the mill through 1985, although production is likely to be somewhat lower. Grade at the Thompson open-pit is 2.7 per cent, which is more than three times that of the Pipe open-pit and production from the Thompson pit will certainly enhance the already cost-competitive nature of these operations.

Sherritt Gordon Mines Limited increased annual capacity in 1983 of its Fort Saskatchewan, Alberta refinery to 21 000 t of contained nickel from 17 500 t. In 1984, the plant operated near capacity for most of the year, although production was adversely affected in October due to technical difficulties. Inco Thompson continued to be the major source of feed.

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## WORLD DEVELOPMENTS

Producers continued to operate well below capacity in response to depressed market conditions. Production increased in 1984 over 1983 but producer inventories still decreased due to higher consumption.

In Australia, Queensland Nickel Pty. Ltd. increased production in the first half of 1984 at its Greenvale mine and refinery, to 70 per cent of capacity from 50 per cent. The complex is capable of producing 21 800 tpy of contained nickel in oxide sinter. Agnew Mining Co. Pty Limited re-evaluated its plans to expand production at its nickel mine in western Australia, given the low prevailing nickel price.

Société Métallurgique Le Nickel (SLN) in New Caledonia was expected to have produced close to 35 000 t of nickel in 1984, compared to 26 000 t a year earlier. Late in the year, production was disrupted for two weeks at the Thio mine by Melanesian militants, who have been compaigning for independence. Production continued at SLN's other mine at Kouaoua and some intermittent shipments from this mine, along with stockpiled ore, kept smelter production at normal rates. The third Demag furnace had been brought back on-stream on August 1, 1984.

Marinduque Mining & Industrial Corporation at Surigao in the Philippines completed its oil to coal conversion plan in June 1983, and in December closed due to lack of working capital. Some spare parts and other supplies were lacking. In August 1984, the Development Bank of the Philippines and the Philippine National Bank, which together had held 87 per cent equity in the company as well as outstanding loans of $1.4 billion, decided to foreclose. A new company, Nonoc Mining & Industrial Corporation, wholly-owned by the banks, took 100 per cent equity in the operation and eliminated the loans. Production subsequently resumed but was then disrupted from early-September until November as the result of typhoon damage.

Ni-Cal Developments Ltd. reported in October, 1984 that it had received a letter of intent from the Development Bank of the Philippines regarding a partial retrofit of the Nonoc refinery. A feasibility study was scheduled to be completed by year-end. If the study was favourable, then Ni-Cal would arrange financing for, construct and operate a single module 770 tpd ore acid leach unit, at Nonoc. Cost would be about $50 million. A full retrofit would involve a facility 10 times this size. The Ni-Cal acid leach technology has not yet been applied commercially.

Start-up problems continued to affect production at the Cerro Matoso SA ferronickel complex in Colombia. Difficulties arose due to the acidic nature of the ore which eroded the furnace lining at the matte-slag interface. Cerro Matoso reduced its electrical power to the furnace, blended the ore more thoroughly, altered the manner in which the ore was loaded into the furnace and took other measures to reduce the problem. Cerro Matoso expects to have a long-term solution in place in 1985, when an Outokumpu Oy cooling system should be operational.

AMAX Inc. obtains matte for its Port Nickel, Louisiana refinery from BCL Ltd. in Botswana and Agnew Mining in Australia, but these sources are insufficient to keep the refinery operating at capacity. AMAX closed the complex for two months in the summer of 1983 and for five weeks in 1984.

Also in the United States, The Hanna Mining Company reopened its ferronickel operations in Riddle, Oregon in November 1983 and continued to operate through 1984 at about one-half capacity. Hanna installed a casting machine in the summer of 1984 and was testing two grades of nickel nuggets. One type contains 50 per cent nickel for use in the stainless steel sector and the other 60 per cent nickel for application in the plating industry.

Effective December 22, 1983, the United States banned all unfabricated nickel and nickel-bearing materials imported directly or indirectly from the U.S.S.R. because it was believed that the Soviet refined product contained some Cuban nickel. The Soviet Union annually imports about 19 000 t of nickel in oxide from Cuba for refining at Monchegorsk in the Kola Peninsula. It was some of this material that was considered to have been shipped to the United States. Unlike the ban on Cuban nickel, the ban on Soviet nickel does not apply to nickel-bearing materials which have been combined with other elements in a third country to form different metals, such as nickel alloys or stainless steel, and then exported to the United States.

In 1984, Comecon exports to the west declined to about 25 000 t from 35 000 t in 1983. The U.S. ban, along with concern by some consumers that it could be expanded to cover alloys containing nickel, likely affected exports but there were other factors as well. It was rumoured that one reason for the decline was that the U.S.S.R. had switched some of the Norilsk production from nickel to copper, in order to meet internal needs for copper.

Cuba continued development of the Punta Gorda complex and full production from the three lines - which have a capacity of 30 000 tpy of contained nickel - is planned for the end of 1985. Preliminary work commenced on a twin plant at Las Camariocas, 20 km away, with production scheduled for the late-1980s. If the planned timetable is met, Cuba will have a capacity of 100 000 t of contained nickel by 1990.

In 1984, Yugoslavia commenced production from its new Kosovo ferronickel plant, and also closed its Feni Kavadarci operation. Kosovo, with a capacity of 12 000 tpy of contained nickel, started producing on May 23. Feni, which had been open for a little over a year, was plagued by high operating costs and intermittent energy supplies. With low nickel prices prevailing, the facility was closed in July. The 2,000 workers were to be relocated to other industries in the region but the plant was being maintained for possible production in the future, if the nickel price increases substantially.

China announced that it would be modernizing and expanding its nickel plant at Jinchuan in the Gansa province. Outokumpu of Finland was granted a licensing agreement for a new 350 000 tpy flash smelter and Western Mining Corporation Ltd. obtained a consultancy agreement to advise on the design and construction of the smelter. The original plant had been brought into production in the mid-1960s.

In South Africa, Western Platinum Limited started construction of a nickel-copper-cobalt-precious metals refinery at Rustenburg. Production is expected in 1986. The plant will utilise Sherritt Gordon's sulphuric acid leach process to make 1 800 tpy of nickel in nickel sulphate and 1 100 tpy of copper cathode. Falconbridge, which owns 25 per cent of Western Platinum, will continue to refine the matte in Norway until the new refinery is operational.

## NICKEL DEVELOPMENT INSTITUTE

In recent years, only limited resources have been expended on promoting the use of nickel and in researching new uses for nickel. Inco formerly led this effort but, with weak market conditions, Inco and other nickel producing companies were forced to reduce their expenditures in this area.

On May 31-June 1, 1984, a meeting of western world nickel producers was held to discuss the need for an international organization to conduct this work. An organization, the Nickel Development Institute (NiDI) was subsequently formed with headquarters in Toronto. While the members are all nickel producers, it is planned that after an initial phase, consumers will also be invited to become members.

The primary emphasis of the NiDI will be to promote the use of nickel in the major markets of the United States, Japan and western Europe. Research will also be conducted into new uses for nickel.

## INTERGOVERNMENTAL NICKEL DISCUSSION GROUP

Thirty-one countries attended an exploratory meeting in October 1984 in Geneva, to discuss the need for an Intergovernmental Nickel Discussion Group (INDG) which would publish statistics and conduct special studies. These countries represented over 95 per cent of world production and 90 per cent of consumption. Canada and Australia hosted the session. As well, there were observers from the Commission of the European Communities, the GATT, the UNCTAD and the International Lead and Zinc Study Group.

There was broad recognition expressed that there are serious information gaps with respect to the world nickel economy, in terms of the quality, timeliness and international comparability of available statistics. Most delegations indicated a willingness and ability to improve the quality of nickel data they provide for publication.

Many countries expressed a preference for an organization similar to the International Lead and Zinc Study Group (ILZSG), an autonomous intergovernmental organization which has proven highly successful over its 25-year history. Some other delegations felt that further reflection would be required on the final character of the organization.

It was agreed that another meeting would be held in the spring of 1985, with UNCTAD to provide the meeting facilities and to arrange for distribution of documentation. Australia and Canada were requested to continue their roles in the preparation of documentation.

## PRICES

Nickel prices advanced on the London Metal Exchange (LME) early in 1983, from an average $US 1.72 in January to $2.19 by March and remained near that level through the rest of 1983 and through 1984. In December 1984, the average LME quote was $2.18.

This price stability occurred despite some wide fluctuations in LME stock levels. At the end of February 1983 nickel stocks were 9 800 t, they then increased steadily to peak at 32 600 t in February 1984 and then declined to 7 400 t by December 29.

Overall stocks, producer, consumer, trade and commodity exchanges declined slightly through 1983 and 1984 but not enough to affect prices. Producers increased output at a rate which was fairly close to the higher consumption levels.

## USES

Resistance to corrosion, high strength over a wide temperature range, pleasing appearance and suitability as an alloying agent are characteristics of nickel which make it useful in a wide range of applications. The major use is in stainless steels, which account for close to 50 per cent of consumption, followed by nickel-base alloys, electroplating, alloy steels, foundry and copper-based alloys. Nickel is extensively used as an alloying agent and is a component in some 3,000 different alloys.

Close to two-thirds of nickel consumption is in capital goods with the remainder used in consumer products. Nickel is used in chemical and food processing, nuclear power plants, aerospace equipment, motor vehicles, oil and gas pipelines, electrical equipment, machinery, batteries, catalysts, and in many other applications.

Relatively new end-use markets that will contribute to nickel's consumption growth in the future are pollution abatement equipment, cryogenic containers, barnacle-resisting copper-nickel alloy plating for boathulls, and nickel-cadmium batteries for standby power applications. The use of nickel-zinc batteries in electric cars was earlier considered to be an important nickel market which would develop in the late 1980s, but the large scale production of electric cars has been deferred. The fledgling solar energy industry could provide a market for increasing amounts of nickel alloys where there is a need for durability and corrosion resistance.

## OUTLOOK

The intensity of nickel use, expressed in terms of consumption per unit of gross national product, has been declining in some major market areas in recent years. While this trend could continue in several of the major industrial economies, the intensity of use is also likely to increase in some growing markets such as India, Brazil, China and the Republic of Korea.

Nickel is expected to lose markets in certain applications to other metals, as well as to ceramics, plastics, composites and some other materials. For example, there is expected to be continued penetration of certain nickel-containing stainless steel markets by non-nickel stainless steel. However, nickel is also expected to substitute for other materials in some applications, particularly since the price of nickel is not expected to increase markedly in real terms for several years. Nickel is far cheaper to use as alloying agent than it was three or four years ago.

Superalloys containing nickel provide an attractive area for growth in certain applications. Continued research in the composition of these alloys and in the techniques of producing them should increase the market penetration of these alloys. As an example of the effects of the research, the U.S. Air Force has developed two nickel aluminide superalloys which are being tested for use in gas turbines of military jet engines. A relatively new class of materials, low-expansion nickel superalloys containing nickel-iron-cobalt, have already proven to offer good potential for use in gas turbines.

Overall, consumption of nickel in the western world is expected to grow at an annual rate of about 1.7 per cent to 1990, from a 1981 base, and then at 1.6 per cent to the year 2000. While these rates are substantially lower than the average 6 per cent annual rate which prevailed for many years prior to the early 1970s, they are still better than the flat rate of the past decade.

In response to the higher levels of demand, production in Canada is expected to increase slowly to the year 2000. There are various constraints to the rate of increases in production. Environmental limits on $SO_2$ emissions is one of the key ones, particularly at Inco, Sudbury. A significant sustained rise in the price of nickel will be needed to permit Inco to regain the financial capability to build a new smelter, which could permit higher output, depending upon potential new government regulations. At Falconbridge, Sudbury considerable expensive mine development work needs to be done before production can be increased to near capacity.

Nickel prices are expected to increase in real terms over the long-term, as production overcapacity is reduced. Other than for a planned expansion of capacity in Cuba, there is not expected to be much new capacity brought on-stream by 1990. With consumption increasing this will bring a better balance between available supply and demand. In constant 1984 $US, the realized price for producers could be close to $3.00 per pound by 1990 and remain at that level through the 1990s.

In the short-term we believe primary nickel consumption will increase less quickly than it has in the past two years. With the strong stainless steel sector in 1984, there will be more scrap available in 1985 and this will have a negative impact upon demand for primary nickel. According to a recent OECD report, GNP growth is expected to be 3 per cent in the United States in 1985, compared to 6.75 per cent in 1984 and 5 per cent in Japan in 1985, compared to 5.75 in 1984. Growth in other major OECD countries is also forecast to be relatively strong. On this basis, primary nickel consumption is forecast to increase between 2 and 3 per cent in 1985.

Nickel prices are expected to firm in 1985 as market fundamentals improve, and nickel on the LME could average in the $US 2.30-2.45 range.

| Item No. | | General Preferential | British Preferential | Most Favoured Nation | General |
|---|---|---|---|---|---|
| CANADA | | | | | |
| 32900-1 | Nickel ores | free | free | free | free |
| 33506-1 | Nickelous oxide | 9% | 10% | 13.8% | 25% |
| 35500-1 | Nickel and alloys containing 60% or more nickel by weight, not otherwise provided for, viz: ingots, blocks and shot; shapes or sections, billets, bars and rods, rolled, extruded or drawn (not including nickel processed for use as anodes); strip; sheet and plate (polished or not); seamless tube | free | free | free | free |
| 35505-1 | Rods containing 90% or more nickel, when imported by manufacturers of nickel electrode wire for spark plugs, for use exclusively in manufacture of such wire for spark plugs in their own factories | free | free | free | 10% |
| 35510-1 | Metal alloy strip or tubing, not being steel strip or tubing, containing not less than 30% by weight of nickel and 12% by weight of chromium, for use in Canadian manufactures | free | free | free | 20% |
| 35515-1 | Nickel and alloys containing 60% by weight or more of nickel, in powder form | free | free | free | free |
| 35520-1 | Nickel or nickel alloys, namely: matte, sludges, spent catalysts and scrap and concentrates other than ores | free | free | free | free |
| 35800-1 | Anodes of nickel | free | free | free | 10% |
| 37506-1 | Ferronickel | free | free | 4.7% | 5% |
| 44643-1 | Articles of nickel or of which nickel is the component material of chief value, of a class or kind not made in Canada, when imported by manufacturers of electric storage batteries for use exclusively in manufacture of such storage batteries in own factories. | 5.5% | 8.8% | 8.4% | 20% |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | (%) | | | | |
| 33506-1 | 13.8 | 13.4 | 13.1 | 12.8 | 12.5 |
| 37506-1 | 4.7 | 4.5 | 4.3 | 4.2 | 4.0 |
| 44643-1 | 8.4 | 8.0 | 7.6 | 7.2 | 6.8 |

**TARIFFS** (cont'd)

| Item No. | | General Preferential | British Preferential | Most Favoured Nation | General |
|---|---|---|---|---|---|
| UNITED STATES | | | | | |
| 419.72 | Nickel oxide | | free | | |
| 423.90 | Mixtures of two or more inorganic compounds in chief value of nickel oxide | | free | | |
| 601.36 | Nickel ore | | free | | |
| 603.60 | Nickel matte | | free | | |
| 606.20 | Ferronickel | | free | | |
| 620.03 | Unwrought nickel | | free | | |
| 620.04 | Nickel waste and scrap | | free | | |
| 620.32 | Nickel powders | | free | | |
| 620.47 | Pipe and tube fittings if Canadian article and original motor vehicle equipment | | free | | |

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 419.70 | Nickel chloride | 4.4 | 4.2 | 4.0 | 3.9 | 3.7 |
| 419.74 | Nickel sulfate | 4.1 | 3.9 | 3.7 | 3.4 | 3.2 |
| 419.76 | Other nickel compounds | 4.4 | 4.2 | 4.0 | 3.9 | 3.7 |
| 426.58 | Nickel salts: acetate | 4.4 | 4.2 | 4.0 | 3.9 | 3.7 |
| 426.62 | Nickel salts: formate | 4.4 | 4.2 | 4.0 | 3.9 | 3.7 |
| 426.64 | Nickel salts: other | 4.4 | 4.2 | 4.0 | 3.9 | 3.7 |
| 620.08 | Nickel plates and sheets, clad | 9.0 | 8.3 | 7.5 | 6.8 | 6.0 |
| 620.10 | Other wrought nickel, not cold worked | 4.3 | 4.1 | 3.9 | 3.7 | 3.5 |
| 620.12 | Other wrought nickel, cold worked | 5.9 | 5.6 | 5.3 | 5.0 | 4.7 |
| 620.16 | Nickel, cut, pressed or stamped to nonrectangular shapes | 7.3 | 6.8 | 6.4 | 5.9 | 5.5 |
| 620.20 | Nickel rods and wire, not cold worked | 4.4 | 4.2 | 4.0 | 3.9 | 3.7 |
| 620.22 | Nickel rods and wire, cold worked | 5.9 | 5.6 | 5.3 | 5.0 | 4.7 |
| 620.26 | Nickel angles, shapes and sections | 7.3 | 6.8 | 6.4 | 5.9 | 5.5 |
| 620.30 | Nickel flakes, per pound | 2.5¢ | 1.9¢ | 1.2¢ | 0.6¢ | free |
| 620.40 | Pipes, tubes and blanks, not cold worked | 2.8 | 2.7 | 2.6 | 2.6 | 2.5 |
| 620.42 | Pipes, tubes and blanks, cold worked | 3.5 | 3.4 | 3.3 | 3.1 | 3.0 |
| 620.46 | Pipe and tube fittings | 6.3 | 5.6 | 5.0 | 4.3 | 3.6 |
| 620.50 | Electroplating anodes, wrought or cast, of nickel | 4.4 | 4.2 | 4.0 | 3.9 | 3.7 |
| 642.06 | Nickel wire strand | 5.9 | 5.6 | 5.3 | 5.0 | 4.7 |
| 657.50 | Articles of nickel, not coated or plated with precious metal | 7.3 | 6.8 | 6.4 | 5.9 | 5.5 |

Sources: The Customs Tariff and Commodities Index, January 1983, Revenue Canada; Tariff Schedules of the United States Annotated 1983, USITC Publication 1317; U.S. Federal Register, Vol. 44, No. 241.

TABLE 1. CANADA, NICKEL PRODUCTION, TRADE AND CONSUMPTION, 1982-84

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Production**[1] | | | | | | |
| All forms | | | | | | |
| Ontario | 62 564 | 429,271 | 94 621 | 595,165 | 138 417 | 925,871 |
| Manitoba | 26 017 | 171,665 | 27 215 | 171,186 | 35 778 | 239,320 |
| Total | 88 581 | 600,936 | 121 836 | 766,351 | 174 195 | 1,165,191 |
| | | | | | (Jan. - Sept. 1984) | |
| **Exports** | | | | | | |
| Nickel in ores, concentrates and matte[2] | | | | | | |
| Norway | 19 736 | 136,888 | 22 812 | 116,908 | 24 646 | 151,815 |
| United Kingdom | 7 299 | 50,925 | 17 271 | 116,654 | 20 356 | 140,889 |
| Japan | 2 | 5 | 4 | 33 | - | - |
| United States | - | - | - | - | 119 | 341 |
| Total | 27 037 | 187,818 | 40 087 | 233,595 | 45 121 | 293,045 |
| Nickel in oxides | | | | | | |
| United States | 4 733 | 36,363 | 5 501 | 44,631 | 5 895 | .. |
| EEC | 5 285 | 40,599 | 2 237 | 18,149 | 1 590 | .. |
| Other countries | 3 109 | 23,888 | 3 429 | 27,821 | 5 966 | .. |
| Total | 13 127 | 100,850 | 11 167 | 90,601 | 13 451 | 98,249 |
| Nickel and nickel alloy scrap | | | | | | |
| United States | 2 123 | 7,141 | 2 524 | 10,176 | 2 990 | 13,214 |
| Netherlands | 622 | 775 | 329 | 1,526 | 3 328 | 17,579 |
| Austria | - | - | 61 | 410 | - | - |
| South Korea | 92 | 630 | 19 | 79 | 131 | 804 |
| Other countries | 433 | 1,430 | 54 | 145 | 1 394 | 6,877 |
| Total | 3 270 | 9,976 | 2 987 | 12,336 | 7 843 | 38,474 |
| Nickel anodes, cathodes, ingots, rods | | | | | | |
| United States | 36 937 | 251,851 | 37 370 | 232,424 | 32 754 | .. |
| EEC | 12 974 | 88,462 | 17 364 | 107,996 | 11 032 | .. |
| Other countries | 12 403 | 84,569 | 12 215 | 75,971 | 14 654 | .. |
| Total | 62 314 | 424,882 | 66 949 | 416,391 | 58 440 | 351,004 |
| Nickel and nickel alloy fabricated material, nes | | | | | | |
| United States | 8 385 | 65,751 | 7 745 | 62,465 | 6 439 | 49,925 |
| South Africa | 244 | 2,334 | 676 | 5,332 | 10 | 96 |
| Belgium-Luxembourg | 256 | 1,427 | 603 | 3,367 | 405 | 3,076 |
| Hong Kong | - | 5 | 540 | 3,015 | 27 | 183 |
| United Kingdom | 259 | 2,133 | 221 | 1,862 | 237 | 1,629 |
| Japan | 460 | 1,769 | 134 | 1,028 | 260 | 1,760 |
| Other countries | 804 | 7,852 | 447 | 3,165 | 425 | 3,245 |
| Total | 10 408 | 81,271 | 10 366 | 80,234 | 7 803 | 59,914 |
| **Imports** | | | | | | |
| Nickel in ores, concentrates and scrap | | | | | | |
| Australia | 4 496 | 20,867 | 6 601 | 23,492 | 2 718 | 11,483 |
| United States | 9 324 | 12,568 | 12 316 | 15,011 | 6 745 | 10,548 |
| United Kingdom | 434 | 556 | 2 106 | 3,676 | 5 272 | 8,476 |
| Belgium-Luxembourg | 5 744 | 5,733 | 3 650 | 3,173 | 1 937 | 1,855 |
| Norway | - | - | 2 731 | 2,245 | - | - |
| Other countries | 2 357 | 2,908 | 1 877 | 1,672 | 391 | 605 |
| Total | 22 355 | 42,632 | 29 281 | 49,269 | 17 073 | 21,967 |

**TABLE 1.** (cont'd.)

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) (Jan.-Sept. 1984) | ($000) |
| Nickel anodes, cathodes, ingots, rods | | | | | | |
| Norway | 1 603 | 11,107 | 1 045 | 5,808 | 2 054 | 15,717 |
| United States | 908 | 5,454 | 654 | 4,185 | 741 | 5,022 |
| United Kingdom | 37 | 314 | 444 | 3,850 | 39 | 266 |
| Netherlands | 18 | 78 | 122 | 815 | - | - |
| Other countries | 22 | 68 | 92 | 472 | 22 | 141 |
| Total | 2 588 | 17,121 | 2 357 | 15,130 | 2 856 | 21,146 |
| Nickel alloy ingots, blocks, rods and wire bars | | | | | | |
| United States | 969 | 6,891 | 607 | 6,487 | 449 | 5,270 |
| Dominican Republic | - | - | 347 | 692 | - | - |
| West Germany | 1 | 6 | 42 | 269 | 26 | 163 |
| Belgium-Luxembourg | - | - | 2 | 13 | - | - |
| Total | 970 | 6,897 | 998 | 7,461 | 475 | 5,435 |
| Nickel and alloy plates, sheet, strip | | | | | | |
| United States | 934 | 8,411 | 424 | 5,626 | 382 | 5,249 |
| West Germany | 388 | 2,802 | 508 | 3,078 | 372 | 2,561 |
| Sweden | - | - | 26 | 161 | 5 | 29 |
| Other countries | 2 | 40 | 1 | 10 | 6 | 49 |
| Total | 1 324 | 11,253 | 959 | 8,875 | 765 | 7,888 |
| Nickel and nickel alloy pipe and tubing | | | | | | |
| Sweden | 600 | 6,881 | 325 | 4,518 | 246 | 2,519 |
| United States | 314 | 5,329 | 106 | 2,041 | 100 | 1,677 |
| West Germany | 108 | 1,752 | 70 | 958 | 45 | 695 |
| Other countries | 48 | 466 | 24 | 389 | 28 | 435 |
| Total | 1 070 | 14,428 | 525 | 7,906 | 419 | 5,326 |
| Nickel and alloy fabricated material, nes | | | | | | |
| United States | 592 | 14,172 | 516 | 11,147 | 350 | 8,540 |
| United Kingdom | 212 | 2,133 | 125 | 1,050 | 26 | 473 |
| West Germany | 34 | 381 | 66 | 498 | 49 | 447 |
| Japan | 3 | 8 | 4 | 16 | 1 | 4 |
| Other countries | 7 | 77 | - | 15 | 10 | 89 |
| Total | 838 | 16,771 | 711 | 12,726 | 436 | 9,553 |
| **Consumption**[3] | 6 637 | .. | .. | .. | .. | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Refined nickel and nickel in oxides and salts produced, plus recoverable nickel in matte and concentrates exported.

[2] For refining and re-export. [3] Consumption of nickel, all forms (refined metal and in oxides and salts) as reported by consumers.

P Preliminary; - Nil; .. Not available; nes Not elsewhere specified.

## TABLE 2. CANADA, NICKEL PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975, 1979-83

| | | Exports | | | | | |
|---|---|---|---|---|---|---|---|
| | Production[1] | In Matte etc. | In Oxide Sinter | Refined Metal | Total | Imports[2] | Consumption[3] |
| | | | | (tonnes) | | | |
| 1970 | 277 490 | 88 805 | 39 821 | 138 983 | 267 609 | 10 728 | 10 699 |
| 1975 | 242 180 | 84 391 | 38 527 | 91 164 | 214 082 | 12 847 | 11 308 |
| 1979 | 126 482 | 42 735 | 17 190 | 84 809 | 144 734 | 2 516 | 8 336 |
| 1980 | 184 802 | 42 647 | 16 989 | 88 125 | 147 761 | 4 344 | 9 676 |
| 1981 | 160 247 | 53 841 | 14 390 | 79 935 | 148 166 | 2 335 | 8 603r |
| 1982 | 88 581 | 27 037 | 13 127 | 62 314 | 102 478 | 2 588 | 6 637 |
| 1983P | 121 836 | 40 087 | 11 167 | 66 949 | 118 203 | 2 357 | 5 015 |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Refined metal and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates exported; [2] Refined nickel, comprising anodes, cathodes, ingots, rods and shot; [3] Consumption of nickel, all forms (refined metal, and in oxides and salts), as reported by consumers.
P Preliminary; r Revised.

## TABLE 3. CANADIAN PROCESSING CAPACITY, 1984

| | Inco | | | Falconbridge | Sherritt Gordon |
|---|---|---|---|---|---|
| | Port Colborne | Sudbury | Thompson | Sudbury | Fort Saskatchewan |
| | (tpy of contained nickel) | | | | |
| Smelter | n.a. | 127 000[1] | 81 600 | 45 000 | n.a. |
| Refinery | 65 000[2] | 56 700 | 55 000 | n.a. | 17 500 |

[1] Reduced from 154 200 t due to a government regulation on $SO_2$ emissions imposed in 1980.
[2] Electrolytic nickel portion of refinery closed in 1984, only utility being produced at year end.
n.a. Not applicable.

### TABLE 4. WORLD MINE PRODUCTION OF NICKEL, 1982 AND 1983

| | 1982 | 1983 |
|---|---|---|
| | (tonnes) | |
| U.S.S.R. | 170 000 | 175 000 |
| Canada[1] | 88 600 | 121 800 |
| Australia | 88 600 | 78 700 |
| New Caledonia | 60 100 | 45 000 |
| Cuba | 37 600 | 39 000 |
| Indonesia | 48 500 | 38 400 |
| South Africa | 20 500 | 20 500 |
| Dominican Republic | 6 000 | 20 200 |
| Botswana | 17 800 | 18 200 |
| People's Republic of China | 12 000 | 15 000 |
| Other | 33 900 | 78 100 |
| Total | 625 100 | 649 900 |

Sources: Energy, Mines and Resources Canada; World Bureau of Metal Statistics.

[1] Refined nickel and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates produced.

### TABLE 5. WORLD CONSUMPTION OF NICKEL, 1982 AND 1983

| | 1982 | 1983 |
|---|---|---|
| | (tonnes) | |
| U.S.S.R. | 138 000 | 140 000 |
| United States | 94 300 | 127 800 |
| Japan | 106 700 | 114 800 |
| Germany, F.R. | 57 700 | 63 000 |
| France | 31 800 | 32 500 |
| Italy | 24 000 | 22 500 |
| United Kingdom | 22 500 | 21 800 |
| People's Republic of China | 19 000 | 19 000 |
| Sweden | 15 000 | 16 400 |
| India | 11 000 | 13 000 |
| Other | 60 500 | 101 000 |
| Total | 624 500 | 671 300 |

Sources: World Bureau of Metal Statistics; Energy, Mines and Resources Canada; U.S. Department of the Interior.

## TABLE 6. FORECAST OF CANADIAN MINE PRODUCTION

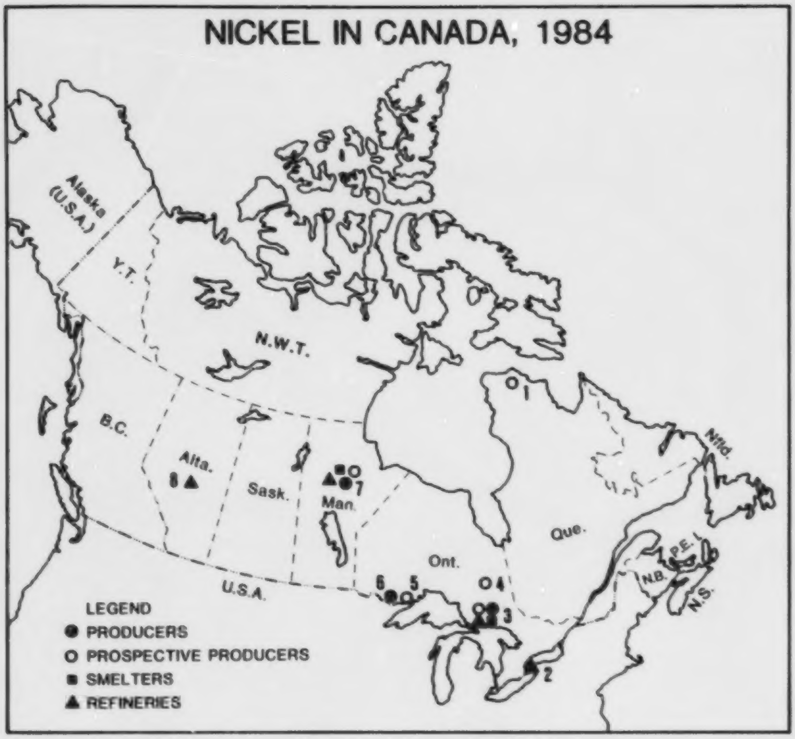
| Year | Inco |  | Falconbridge |  |
|---|---|---|---|---|
|  | Sudbury[1] | Thompson | Sudbury | Total |
|  | (tonnes) |  |  |  |
| 1985 | 106 000 | 35 000 | 33 000 | 174 000 |
| 1986 | 107 000 | 42 000 | 33 500 | 182 500 |
| 1987 | 108 000 | 45 000 | 33 500 | 186 500 |
| 1988 | 108 000 | 49 000 | 34 000 | 191 000 |
| 1989 | 109 000 | 50 000 | 35 000 | 194 000 |
| 1990 | 110 000 | 50 000 | 35 500 | 195 500 |
| 1991 | 110 000 | 50 000 | 33 000 | 193 000 |
| 1992 | 110 000 | 50 000 | 33 000 | 193 000 |
| 1993 | 111 000 | 50 000 | 34 000 | 195 000 |
| 1994 | 111 000 | 50 000 | 34 000 | 195 000 |
| 1995 | 111 000 | 50 000 | 35 000 | 196 000 |
| 1996 | 112 000 | 50 000 | 35 000 | 197 000 |
| 1997 | 113 000 | 50 000 | 35 000 | 198 000 |
| 1998 | 114 000 | 50 000 | 36 000 | 200 000 |
| 1999 | 115 000 | 50 000 | 36 000 | 201 000 |
| 2000 | 116 000 | 50 000 | 37 000 | 203 000 |

[1] Includes Shebandowan.

## TABLE 7. NICKEL PRICES IN UNITED STATES DOLLARS PER POUND, 1983

|  | 1st Quarter Average | 2nd Quarter Average | 3rd Quarter Average | 4th Quarter Average | Annual Average |
|---|---|---|---|---|---|
| Cathodes |  |  |  |  |  |
| - New York dealer[1] | 1.98 | 2.31 | 2.27 | 2.17 | 2.18 |
| - major producer | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 |
| LME CASH | 1.94 | 2.22 | 2.20 | 2.10 | 2.12 |
| Briquettes/Western | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 |
| Falconbridge, ferronickel[1] | 3.18 | 3.18 | 3.18 | 3.18 | 3.18 |
| Hanna, ferronickel[1] | 3.16 | 3.16 | 3.16 | 3.16 | 3.16 |

Source: Metals Week.
[1] Per pound of contained nickel.


NICKEL IN CANADA, 1984
Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
1
2
3
4
5
6
7
8
LEGEND
● PRODUCERS
○ PROSPECTIVE PRODUCERS
■ SMELTERS
▲ REFINERIES

**Producers, prospective producers, smelters and refineries**
(numbers refer to locations on map above)

**Producers**

3. Falconbridge Limited
   (East, Falconbridge, Fraser, Lockerby, North, Strathcona
   Inco Limited
   Clarabelle, Copper Cliff North, Copper Cliff South, Creighton, Frood, Garson, Levack, Little Stobie, McCreedy West and Stobie)
6. Inco Limited (Shebandowan mine)
7. Inco Limited (Pipe open pit and Thompson)

**Prospective Producers**

1. New Quebec Raglan Mines Limited
3. Falconbridge Limited
   (Craig, Lindsley, Onaping, Onex, Thayer mines)
   Inco Limited (Coleman, Crean Hill, Murray, Totten)
4. Teck Corporation (Moncalm Township)
5. Great Lakes Nickel Limited (Pardee Township)
7. Inco Limited (Thompson open pit, Soab, North, Soab, South, Birchtree, Pipe No. 1)

**Smelters**

3. Falconbridge Limited (Falconbridge)
3. Inco Limited (Sudbury)
7. Inco Limited (Thompson)

**Refineries**

2. Inco Limited (Port Colborne)
3. Inco Limited (Sudbury)
7. Inco Limited (Thompson)
8. Sherritt Gordon Mines Limited (Fort Saskatchewan)

# Phosphate

G.S. BARRY

Naturally occurring rock deposits are the most common source of phosphorus; other sources are bones, guano, and some types of iron ores that yield byproduct basic slag containing sufficient phosphorus to warrant grinding and marketing.

Phosphate rock, contains one or more suitable phosphate minerals, usually calcium phosphate, in sufficient quantity for use, either directly or after beneficiation, in the manufacture of phosphate products. Sedimentary phosphate rock, or phosphorite, is the most widely used phosphate raw material. Apatite, which is second in importance, occurs in many igneous and metamorphic rocks.

Phosphate rock is graded either on the basis of its $P_2O_5$ equivalent (phosphorus pentoxide) or its $Ca_3(PO_4)_2$ content (tricalcium phosphate of lime or bone phosphate of lime - TPL or BPL). For comparative purposes, 0.458 unit $P_2O_5$ equals 1.0 unit BPL, and 1 unit of $P_2O_5$ contains 43.6 per cent phosphorus.

Approximately 80 per cent of world phosphorus production goes into fertilizers; other products which require the use of phosphorus include organic and inorganic chemicals, soaps and detergents, pesticides, insecticides, alloys, animal-food supplements, motor lubricants, ceramics, beverages, catalysts, photographic materials, and dental and silicate cements.

A severe world contraction in the demand for phosphatic fertilizers began in 1981 and continued until mid-1983. Since that time there is a clear steady improvement in phosphate markets which as measured by deliveries of phosphate rock rose by 11.7 per cent from 123.3 million t in 1982 to 137.8 million t in 1983. There was further improvement in the first nine months of 1984 with deliveries by major western world producers advancing by 13.5 per cent (68.9 million t in 1984 compared to 60.7 million t in 1983). It is estimated that world phosphate rock production in 1984 will exceed the record of 139.4 million t achieved in 1981 by two to three million t. A further positive element is a decrease in stocks held by producers, particularly in the USA. Stocks held by major western world producers were 34.2 million t at their peak on July 1, 1982 and declined to 22.2 million t on October 1, 1984. Among the traditional large producers and exporters, Brazil, Israel, Jordan, Morocco, Senegal, Togo, Tunisia and the USA recorded increased production while only South Africa and Syria experienced cutbacks in 1983, whereas in 1984 only South Africa and Tunisia experienced a significant decline. Iraq brought new production on stream. The United States which experienced an unprecedented drop in production of 30 per cent between 1981 and 1982, recorded in 1983 a 8.5 per cent increase in production and a 21 per cent increase in deliveries. A further production increase of 18 per cent is estimated for 1984.

World exports of phosphate rock increased by 5.9 per cent from 43.8 million t in 1982 to 46.4 million t in 1983. Exports in 1984 are expected to be over 48 million t.

## OCCURRENCES IN CANADA

Known Canadian deposits are limited and fall into three main categories: apatite deposits within Precambrian metamorphic rocks in eastern Ontario and southwestern Quebec; apatite deposits in some carbonate-alkaline complexes (carbonatites) in Ontario and Quebec; and Late Paleozoic-Early Mesozoic sedimentary phosphate rock deposits in the southern Rocky Mountains. Phosphatic mineralization was also reported in the layered rocks of the Athabasca series.

The deposit of greatest economic significance is the Kapuskasing (Cargill) phosphate deposit, where early studies indicated the presence of about 60 million t of ore grading 20.2 per cent $P_2O_5$. The property was optioned by Sherritt Gordon Mines Limited in 1979 from International Minerals & Chemical Corporation (Canada)

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Limited (IMCC). The option was exercised in December 1983. Preliminary designs for an open pit at Cargill, based on IMCC's grades and tonnages, allowed for the production of 450 000 tpy of 39 per cent $P_2O_5$ concentrates for a minimum of 17 years. Additional drilling, test pits and bulk sample pilot plant testing confirmed the technical viability of this deposit, and a preliminary feasibility study on the mining of higher grade material produced encouraging economics despite the low phosphate prices used in the study.

Another important carbonatite deposit was discovered by Shell Canada Resources Limited near Martison Lake north of Hearst, Ontario. In December 1982 the deposit was purchased by New Venture Equities Ltd. which formed a 50-50 joint venture with Camchib Mines Inc. for further exploration and development. Camchib Mines Inc. is wholly owned by Campbell Resources Inc. The Joint Venture continued with detailed, fill-in drilling on the property and announced in August 1983 that higher grade zones of the deposit contain 57 million t grading 23 per cent $P_2O_5$. A \$1.2 million additional drilling program was completed in 1984.

In July 1984, Sherritt Gordon Mines, Campbell Resources and New Venture Equities combined forces on a 50/50 joint venture on the two phosphate properties at Cargill and Martison Lake. The company is confident that when North American market conditions improve the development at one or both properties could be economic. Depending on these conditions a decision on a full scale feasibility study will be made in 1985.

Additional details on the Canadian phosphate deposits and industry were provided in the publication MR 193, "Phosphate Rock, an Imported Mineral Commodity" (December 1981).

## CANADIAN PHOSPHATE INDUSTRY

**Phosphate Rock.** In 1983, Canada imported only 2.66 million t of phosphate rock; for the first nine months of 1984 imports increased by 25 per cent. The general economic recession was responsible for the low import levels. Imports averaged 3 058 463 t from 1975 to 1981. Approximately 75 per cent of the phosphate rock is used in fertilizer production, 18 per cent in elemental phosphorus production and 6 per cent in calcium phosphate production.

About 70 per cent of Canada's imports of phosphate rock from the United States has been from Florida since the late 1970s. The remainder was from western states. Purchase practices, which include commercial factors as well as the characteristics of rock used by the fertilizer plants, point to the continuation of this pattern of supply for at least several years.

Currently, eastern Canada is supplied from Florida. From 700 000 t to 750 000 t are transported by sea, with three quarters of this total being used for elemental phosphorus production and the remainder for fertilizer production in New Brunswick.

Approximately 450 000 t to 500 000 t of phosphate rock is shipped annually by rail from Florida mines to Ontario fertilizer plants because generally for this part of Canada direct unit train rail service is more advantageous than ocean shipping combined with short overland hauls. The fact that shipments in Florida do not have to be routed via the congested port of Tampa is another positive factor. Another advantage is that railroad shipments can be maintained at a schedule that allows for very low inventories. However, recession related, ocean shipping costs were so low during 1983 and most of 1984, that they were more than competitive, creating a situation where finished fertilizers could be shipped at less than the cost of shipping phosphate rock by rail.

Florida is the source of phosphate rock for about 55 to 60 per cent of the five western Canadian fertilizer plants and western U.S. states for some 40 to 45 per cent. Rock shipped from Florida via the Panama Canal to Vancouver is mainly transported as back-haul to Canadian lumber (to United States) and potash exports (to South America). The inland rail haul from Vancouver to the Edmonton area is a back-haul to exports of potash. Total shipping costs are competitive with rail haul from mines in the western United States.

Belledune Fertilizer (a Division of Noranda Inc.) produced 140 000 t of DAP in 1983 (152 000 t in 1982) at its New Brunswick fertilizer plant. Shipments were higher by some 20 000 t resulting in a substantial fall in inventories. The 1984 DAP production is estimated at over 170 000 t.

International Minerals & Chemical Corporation operated its Port Maitland fertilizer plant at just below 70 per cent capacity. IMCC produced commercial phosphoric acid, single super phosphate (SSP), triple super phosphate (TSP), mono-ammonium phosphate (MAP), and a calcium phosphate. The plant had considerable profitability problems and was closed at the end of June 1984 for an indefinite period (currently the plant is "mothballed" for a duration of about two years).

C-I-L Inc. operated its phosphate plant intermittently, one to two weeks per month averaging less than 50 per cent capacity utilization, and producing about 80 000 t of ammonium phosphates. The company uses smelter and waste sulphuric acid. C-I-L is now expanding its nitrogen capacity from 350 000 t to 750 000 t of ammonia for completion in mid-1985. The company will continue to produce phosphatic fertilizers at the current low production levels.

Cominco Ltd. shut down its Kimberley fertilizer plant for eight weeks in mid-1983 for annual maintenance and inventory control. Production of ammonium fertilizers at the Trail and Kimberley plants combined was 273 000 t in 1983 and 309 000 t in 1984.

Esso Chemical Canada completed its $400 million fertilizer plant expansion during 1983 on target and on budget. Costs for the expansion of the phosphate plant from 204 000 tpy to 370 000 tpy capacity were about $50 million. The phosphate part of the fertilizer plant was actually completed in 1982 but was never put on stream until September 1983. The associated sulphuric acid plant, also completed has not yet been commissioned since the company finds it more economic at present to buy sulphuric acid from Sherritt Gordon and other commercial sources. Since September 1983 production of ammonium phosphates was carried at almost full capacity, with part of the output being tolled for Sherritt Gordon Mines.

Western Co-operative Fertilizers Limited operated its Calgary plant throughout the year except for a two-week maintenance shutdown in mid-summer. The plant produced over 200 000 t of ammonium phosphate fertilizers in 1983 and over 250 000 t in 1984, mainly MAP. The Medicine Hat plant remained closed throughout the year. The company imports phosphate rock from Idaho.

Sherritt Gordon Mines closed its phosphate production facilities at the Fort Saskatchewan plant in September 1983 and will remain shut down for two years. During this period requirements for phosphate fertilizer will be provided by Esso Chemical under a tolling agreement. Sherritt will convert Esso's ammonia into a tonnage of urea equivalent to the tonnage of phosphates provided by Esso.

**Elemental phosphorus.** ERCO Industries Limited operates two thermal reduction plants in Canada where elemental phosphorus is produced by the smelting of a mixture of phosphate rock, coke and silica. One tonne of phosphorus requires the input of about 10 t of phosphate rock (60 to 67 per cent BPL), 2 t of coke and 3 t of silica.

ERCO has plants at Varennes, Quebec with a 22 500 t annual capacity ($P_4$) and at Long Harbour, Newfoundland with an effective capacity of about 60 000 tpy. Until recently the elemental phosphorus production from Long Harbour was almost exclusively reserved for Albright & Wilson, Inc. derivative plants in Europe, but in 1982, 1983 and 1984 a proportion was sent toBuckingham, Quebec and Port Maitland, Ontario to supplement supplies from Varennes, Quebec. In late 1984, ERCO restarted the second main furnace idle since 1982. The company also put on stream the second of two smaller furnaces to recover up to 2 000 t annually of phosphorus from the "mud" produced as a byproduct of furnace operation and "mud" stored on site in the past.

The Long Harbour, Newfoundland plant operated at full capacity during 1983. In total, the ERCO plants use from 600 000 to 650 000 tpy of Florida phosphate rock. Since the low-grade phosphate rock acceptable for thermal reduction cannot be used by the fertilizer industry, it can be purchased at relatively lower prices (per $P_2O_5$ unit value).

Production from Varennes, Quebec is 90 per cent or more oriented toward Canadian markets. The elemental phosphorus ($P_4$) produced at Varennes is shipped to two ERCO plants one at Buckingham, Quebec and the other at Port Maitland, Ontario. At Buckingham about 9 000 tpy of $P_4$ is used to produce technical and food grade phosphoric acid (95 per cent $H_3PO_4$) and 1 000 t to produce amorphous red phosphorus and phosphorus sesquisulphide.

ERCO's Port Maitland plant operates on phosphorus from Varennes and Long Harbour, using about 12 000 tpy. It is all converted to technical grade phosphoric acid.

Coproducts of elemental phosphorus are ferrophosphorus, carbon monoxide and calcium silicate slag. Ferrophosphorus contains 20 to 25 per cent phosphorus and is used by the steel industry as a direct source of the phosphorus needed in some types of steel.

**Phosphate fertilizers.** Nine Canadian plants (Table 3) produce wet phosphoric acid by the dihydrate process in which 28 to 30 per cent $P_2O_5$ acid is the principal product and gypsum is the waste product. Three of the nine plants are now idle. At present, there is no use for the gypsum and it accumulates in large settling ponds near all the plants except one in New Brunswick where it is disposed of in the sea.

Canadian phosphoric acid plants are designed to operate on phosphate rock which grades between 69 and 72 per cent BPL (31.1 to 33.0 per cent $P_2O_5$). The first stage of acid production, which is digestion and filtration, produces "filter acid" grading 28 to 30 per cent $P_2O_5$. This product is then upgraded by evaporation to about 40 to 44 per cent acid for most in-plant use, or to 52 to 54 per cent $P_2O_5$ for commercial sales or specialized uses. The evaporation step is energy intensive, and the provenance of sulphuric acid has a bearing on energy consumption. Plants using elemental sulphur as the source of in-plant sulphuric acid production have their evaporation energy requirements met by heat generated in the sulphuric acid plants since the process is exothermic. (i.e., 1 t of sulphur has a BTU content equivalent to about 2 barrels of oil). Plants using commercial sulphuric acid, (e.g., produced from $SO_2$ smelter gases) have to generate vapour requirements with natural gas or coal-fired boilers. To balance energy requirements, an efficient dihydrate WPA plant could theoretically operate using elemental sulphur for 70 to 75 per cent of its requirements and purchased sulphuric acid for the remainder.

Most phosphate rock contains uranium. It is in small enough quantities not to present any problems for fertilizer production. In Canada, Earth Sciences Inc. (ESI) started a uranium recovery plant in Calgary in 1980. It treats phosphoric acid from the adjoining plant of Western Co-operative Fertilizers Limited, and returns the acid to the owner. The plant was placed on standby in November 1981. The plant underwent major modifications during 1982 and 1983 and was re-opened in May 1983. The recovered yellow cake is shipped to British Nuclear Fuels Ltd. in the United Kingdom for refining and then returned to the United States. In 1982 Urangesellschaft Canada Limited acquired 49 per cent interest in the Calgary ESI plant.

Capacity of Canadian phosphoric acid plants is expressed in 100 per cent $P_2O_5$ equivalent and the total installed annual capacity is currently estimated at 1 146 000 t. Some of this capacity is now idle and mothballed. Efficient plants can consistently operate at 90 to 95 per cent of nameplate capacity. Most Canadian plants, gauge their annual production levels to corporate marketing strategies and fertilizer demand forecasts. At times when agricultural demand is low Canadian production capacities are seriously underutilized. The recovery of $P_2O_5$ from phosphate rock i.e. the efficiency of conversion varies from 88 to 94 per cent.

All of the nine phosphoric acid plants in Canada are integrated to produce phosphatic fertilizers, mainly ammonium phosphates. Ammonium phosphates are produced by a neutralization reaction of phosphoric acid with ammonia and, depending on the proportions of the original constituents, either diammonium phosphate (DAP) (18-46-0) or mono-ammonium phosphate (MAP) (range from 11-48-0 to 11-55-0) are produced. Another common grade particularly in the West is 16-20-0.

Canadian fertilizer plants produce annually between 800 000 t and 950 000 t of mono-ammonium phosphates (MAP), between 250 000 t and 300 000 t of diammonium phosphate (DAP) and about 250 000 t of other ammonium and ammonium-nitrate phosphates. Up to 100 000 t of normal (SSP) and triple (TSP) superphosphate is also produced but this production is on a decline.

**Calcium Phosphate.** Two fertilizer plants in Canada use phosphoric acid for the production of calcium phosphates that are used mainly for supplementing the calcium and phosphorus content of animal and poultry feedstocks. The two products are: monocalcium phosphate (21 per cent phosphorus) or dicalcium phosphate (18.5 per cent phosphorus).

The phosphoric acid used for calcium phosphate production in eastern Canada was all produced by IMCC in Port Maitland, Ontario. The company used more than half for its own requirements and sold the remainder to Cyanamid Canada Inc. which has a nearby plant at Welland. After the mid-1984 closure of the IMCC plant the company supplied markets for these products through imports.

## WORLD DEVELOPMENTS

World phosphate rock production in 1983 was estimated at 130.8 million t, an increase of 8.1 per cent from 1982. Western world production was 91.4 million t, an increase of 8.4 per cent from the year before. In 1984 world phosphate rock production was estimated to exceed 143 million t.

The uptrend in both production and sales was strong in 1983 and 1984, particularly since the second half of 1983 following two and a half years of recession. Major producers like the United States and Morocco increased production by 28.3 and 19.2 per cent respectively between 1982 and 1984. The U.S. producers sales exceeded production allowing for a decline in producers inventories to 14.3 million t at the end of 1983, and to 13.0 million t at the end of September 1984, approaching the low level of 1980. There was an increase in production in the USSR and China. Among lesser but significant world producers Brazil, Israel, Jordan, Norway, Senegal and Tunisia recorded substantial production increases; only South Africa recorded a decline.

The world phosphate rock industry however, still suffered from low prices since there remains a large excess of capacity. In 1983 the approximate utilization of capacity in the USA was only 71 per cent and in Africa 67 per cent. Despite this, a number of large new mines were recently put on stream or are in advanced stages of completion. Table 6 lists 43 important active and potential phosphate mine projects. The timely development of even half of these will ensure ample supply of phosphate rock well into the next century. There is however a continuous decline in the average grade and purity of phosphate rock concentrates and this trend is expected to continue making the development of deposits that will yield exceptionally high grade concentrates such as the Canadian Precambrian deposits progressively more attractive.

## PRICES

Most phosphate rock is purchased under producer-consumer negotiated prices which depart from listed prices in consideration of volume, transportation conditions and local competitive conditions. Phosrock Ltd., a Florida-based marketing organization which represents about two thirds of producers for export markets lists prices as shown in Table 7. International prices are also quoted by Office Cherifien des Phosphates (OCP) fob ports of Safi or Casablanca. are usually $2 to $4 above Tampa prices, the difference reflecting competitive conditions, for "landed" prices to most European destinations.

The average unit price of phosphate rock sold or used in the USA was $US 23.98 per tonne fob plant in 1983 compared to $26.63 in 1981 and $25.50 in 1982. The average value of phosphate rock exported decreased from $US 29.83 per tonne fob mine in 1982 to $27.26 in 1983. For fertilizer year 1983-84 the average unit price was $US 23.94/t.

## OUTLOOK

The outlook for 1985 is for a continuation of higher demand under ample supply conditions. Prices for phosphoric acid and phosphatic fertilizers, although higher than in 1983 and 1984 will remain low, probaby not yet exceeding those of 1982. Under the current marketing conditions prices are 25 to 40 per cent lower than normal renumerative levels. A continuous steady increase in demand after 1985, however will be mirrored by substantially better price movements.

Most experts forecast a consumption growth for phosphate fluctuating between 3.5 and 4.5 per cent annually for the next few years. The USA demand should average 2 per cent growth after the considerable improvement in 1983 and 1984.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| CANADA | | | | | |
| 93100-2 | Phosphate rock | free | free | free | free |
| 66345-1 | Defluorinated calcium phosphates for use in the manufacture of animal or poultry feeds | free | free | free | free |
| 93103-1 | Calcium phosphate dibasic | free | free | free | free |
| 93103-2 | Calcium phosphate, disintegrated, calcined, thermo-phosphates, fused phosphates; superphosphates | free | free | free | free |
| 92840-1 | Phosphites, phosphorus, hypophosphites and phosphates | 10 | 13.8 | 25 | 9 |
| | Sodium phosphate disbasic, and monobasic, pharmacopoeial tribasic, commercial grade; sodium pyrophosphate; sodium tripolyphosphate (temporary rate reduction 3/06/80 to 30/06/87) | free | 13.8 | 25 | free |
| 92840-2 | Di-calcium phosphate | 9.4 | 7.5 | 25 | 5.0 |
| | (temporary rate reduction 3/06/80 to 31/12/86) | free | 7.5 | 25 | free |
| 93100-1 | Fertilizers; goods for use as fertilizers | free | free | free | free |
| 93105-1 | Ammonium phosphates | free | free | free | free |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 92840-1 | 13.8 | 13.4 | 13.1 | 12.8 | 12.5 |
| 92840-2 | 7.5 | 5.6 | 3.8 | 1.9 | free |

UNITED STATES, Customs Tariffs (MFN)

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 420.92 | Sodium phosphate containing over 45% water | 2.8 | 2.7 | 2.7 | 2.6 | 2.5 |
| 421.22 | Pyrophosphates | 4.4 | 4.2 | 4.0 | 3.9 | 3.7 |
| 606.33 | Ferrophosphorus | 4.2 | 3.8 | 3.3 | 2.9 | 2.4 |

Sources: The Customs Tariff, 1983, Revenue Canada; Customs and Excise. Tariff Schedules of the United States Annotated (1983), USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241.

## TABLE 1. CANADA, PHOSPHATE ROCK IMPORTS, 1982-84, AND CONSUMPTION, 1981-34

| | 1982 | | 1983 | | 1984 | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($) | (tonnes) | ($) | (tonnes) | ($) |
| | | | | | (Jan.-Sept. 1984) | |
| **Imports** | | | | | | |
| United States | 2 482 583 | 101,704,000 | 2 662 725 | 102,194,000 | 2 593 556 | 99,097,000 |
| Other countries | 29 141 | 1,503,000 | - | - | - | - |
| | 2 511 724 | 103,207,000 | 2 662 725 | 102,194,000 | 2 593 566 | 99,097,000 |

| | 1981 | 1982 | 1983^e | 1984^e |
|---|---|---|---|---|
| | (tonnes) | (tonnes) | (tonnes) | (tonnes) |
| **Consumption**[1] | | | | |
| Eastern Canada | 1 364 839 | 1 222 520 | 1 132 000 | 1 222 000 |
| Western Canada | 2 217 847 | 1 159 151 | 1 698 000 | 1 807 000 |
| Total | 3 582 686 | 2 381 671 | 2 830 000 | 3 029 000 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Breakdown by Energy, Mines and Resources Canada.

e Estimated; - Nil.

## TABLE 2. CANADA, PHOSPHATE FERTILIZER SHIPMENTS, 1978-84[1]

| | 1978/79 | 1979/80 | 1980/81 | 1981/82^r | 1982/83 | 1983/84 |
|---|---|---|---|---|---|---|
| | (tonnes $P_2O_5$ equivalent) | | | | | |
| Domestic markets: | | | | | | |
| Atlantic provinces | 18 867 | 19 441 | 24 481 | 26 261 | 29 443 | 24 965 |
| Quebec | 23 540 | 20 992 | 28 610 | 34 915 | 43 308 | 37 835 |
| Ontario | 63 379 | 54 602 | 82 496 | 71 033 | 71 959 | 79 166 |
| Manitoba | 89 576 | 110 382 | 97 529 | 75 239 | 81 907 | 90 529 |
| Saskatchewan | 131 636 | 131 500 | 135 534 | 144 998 | 153 784 | 195 170 |
| Alberta | 140 880 | 131 413 | 149 116 | 152 906 | 157 010 | 161 185 |
| British Columbia | 12 440 | 14 204 | 13 308 | 8 998 | 10 970 | 11 311 |
| Total Canada | 480 318 | 482 533 | 531 074 | 514 350 | 548 381 | 600 161 |
| Export markets: | | | | | | |
| United States | 144 670 | 146 813 | 194 565 | 141 411 | 82 478 | 65 790 |
| Offshore | 46 814 | 44 999 | 77 328 | 20 305 | 715 | 4 652 |
| Total exports | 191 484 | 191 812 | 271 893 | 161 716 | 83 193 | 70 442 |
| Total shipments | 671 803 | 674 344 | 802 968 | 676 066 | 631 574 | 670 603 |

Source: Canadian Fertilizer Institute.

[1] Fertilizer year: July 1 to June 30; not 100% industry coverage.

r Revised.

Note: Totals may not add due to rounding.

TABLE 3. CANADA, PHOSPHATE FERTILIZER PLANTS

| Company | Plant Location | Annual Capacity (tonnes) ($P_2O_5$ eq.) | Principal End Products | Source of Phosphate Rock | Basis for $H_2SO_4$ Supply for Fertilizer Plants |
|---|---|---|---|---|---|
| **Eastern Canada** | | | | | |
| Belledune Fertilizer Div. of Noranda Inc. | Belledune, N.B. | 150 000 | am ph | Florida | $SO_2$ smelter gas |
| C-I-L Inc. | Courtright, Ont. | 90 000 | am ph | Florida | $SO_2$ smelter gas, pyrrhotite roast and waste acid |
| International Minerals & Chemical Corporation (Canada) Limited (IMCC) | Port Maitland Ont. | 118 000* | $H_3PO_4$, ss ts, ca ph | Florida | Sulphur and $SO_2$ smelter gas |
| | | 358 000 | | | |
| **Western Canada** | | | | | |
| Cominco Ltd. | Kimberley, B.C. | 86 700 | am ph | Montana and Utah | $SO_2$ pyrite roast |
| | Trail, B.C. | 77 300 | am ph | Utah | $SO_2$ smelter gas |
| Esso Chemical Canada | Redwater, Alta. | 370 000** | am ph | Florida | Sulphur |
| Sherritt Gordon Mines Limited | Fort Saskatchewan, Alta. | 50 000*** | am ph | Florida | Sulphur |
| Western Co-operative Fertilizers Limited | Calgary, Alta. | 140 000 | am ph | Idaho | Sulphur |
| | Medicine Hat, Alta. | 65 000**** | | Idaho | |
| | | 788 000 | | | |
| Canada: installed capacity | | 1 146 000 | | | |
| effective capacity: | | | | | |
| end of 1982 | | 915 000 | | | |
| end of 1983 | | 1 031 000 | | | |
| end of 1984 | | 913 000 | | | |

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$P_2O_5$ eq. Phosphorus pentoxide equivalent; am ph Ammonium phosphates; ss Single superphosphate; ts Triple superphosphate; ca ph Food supplement calcium phosphate; $H_3PO_4$ phosphoric acid for commercial sales.

* Shutdown and mothballed for an indefinite period - July 1984. ** Expansion from 204 000 t to 370 000 t completed in 1982 and put on stream, Sept. 1983. *** Shutdown temporarily for two years - Sept. 1983 to Sept. 1985. **** Shutdown for an indefinite period - May 1982.

### TABLE 4. CANADA, TRADE IN SELECTED PHOSPHATE PRODUCTS, 1982-84

| | 1982 | | 1983P | | 1984<br>9 months | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($) | (tonnes) | ($) | (tonnes) | ($) |
| **Imports** | | | | | | |
| Calcium phosphate | | | | | | |
| United States | 18 216 | 9,917,000 | 34 446 | 16,413,000 | 29 901 | 13,620,000 |
| Other countries | 52 | 37,000 | 733 | 280,000 | 946 | 351,000 |
| Total | 18 268 | 9,954,000 | 35 179 | 16,692,000 | 30 847 | 13,971,000 |
| Fertilizers: | | | | | | |
| Normal superphosphate, 22 per cent or less $P_2O_5$ | | | | | | |
| United States | 188 | 56,000 | 1 368 | 254,000 | 18 | 3,000 |
| Triple superphosphate, over 22 per cent $P_2O_5$ | | | | | | |
| United States | 31 947 | 7,143,000 | 54 755 | 11,562,000 | 30 804 | 6,915,000 |
| Phosphatic fertilizers, nes | | | | | | |
| United States | 216 588 | 61,344,000 | 303 022 | 82,682,000 | 197 410 | 58,903,000 |
| Belgium-Luxembourg | 901 | 547,000 | 673 | 408,000 | 843 | 484,000 |
| Israel | 193 | 149,000 | 299 | 213,000 | 182 | 111,000 |
| United Kingdom | 1 | -- | - | - | - | - |
| Singapore | 4 | 10,000 | - | - | - | - |
| Netherlands | 16 | 8,000 | 101 | 39,000 | 58 | 21,000 |
| Other countries | - | - | 86 | 50,000 | 58 | 24,000 |
| Total | 217 693 | 62,057,000 | 304 181 | 83,392,000 | 198 551 | 59,541,000 |
| Chemicals: | | | | | | |
| Potassium phosphates | | | | | | |
| United States | 1 243 | 1,322,000 | 1 327 | 1,782,000 | 1 194 | 1,725,000 |
| France | 110 | 118,000 | 139 | 150,000 | 136 | 149,000 |
| Israel | 131 | 115,000 | 216 | 195,000 | 138 | 152,000 |
| Netherlands | 8 | 10,000 | 23 | 26,000 | 35 | 42,000 |
| West Germany | - | - | 24 | 37,000 | - | - |
| Total | 1 492 | 1,566,000 | 1 729 | 2,190,000 | 1 503 | 2,068,000 |
| Sodium phosphate, tribasic | | | | | | |
| United States | 408 | 281,000 | 521 | 476,000 | 267 | 223,000 |
| France | 177 | 65,000 | 249 | 98,000 | 166 | 63,000 |
| Belgium-Luxembourg | - | - | 40 | 61,000 | - | - |
| Netherlands | 51 | 21,000 | 84 | 35,000 | 55 | 21,000 |
| People's Republic of China | - | - | 119 | 49,000 | 174 | 75,000 |
| Total | 636 | 367,000 | 1 013 | 719,000 | 662 | 382,000 |
| **Exports** | | | | | | |
| Nitrogen phosphate fertilizers, nes | | | | | | |
| United States | 272 086 | 62,198,000 | 193 724 | 43,052,000 | 128 962 | 28,388,000 |
| Costa Rica | - | - | 5 190 | 1,716,000 | 2 929 | 887,000 |
| Jamaica | - | - | 3 564 | 1,035,000 | 7 183 | 2,123,000 |
| Other countries | - | - | 36 | 15,000 | 28 985 | 7,598,000 |
| Total | 272 086 | 62,198,000 | 202 514 | 45,818,000 | 168 059 | 38,996,000 |

Source: Statistics Canada.
P Preliminary; - Nil; nes Not elsewhere specified; -- Too small to be expressed.

## TABLE 5. WORLD PHOSPHATE ROCK PRODUCTION, 1981-84

| | 1981 | 1982 | 1983 | 1984$^e$ |
|---|---|---|---|---|
| | (000 tonnes product) | | | |
| **WORLD TOTAL** | **139 348** | **122 913** | **134 621** | **143 000** |
| **West Europe** | **372** | **389** | **538** | **600** |
| Finland | 201 | 232 | 381 | |
| Sweden | 128 | 131 | 107 | |
| Turkey | 43 | 26 | 50 | |
| **East Europe** | **26 200** | **27 200** | **27 700** | **28 000** |
| U.S.S.R. | 26 200 | 27 200 | 27 700 | |
| **North America** | **53 624** | **37 414** | **42 187** | **48 000** |
| United States | 53 624 | 37 414 | 42 187 | |
| **Central America** | **252** | **379** | **389** | **400** |
| Mexico | 252 | 379 | 389 | |
| **South America** | **2 791** | **2 779** | **3 229** | **3 500** |
| Brazil | 2 764 | 2 732 | 3 208 | |
| Colombia | 15 | 18 | 18 | |
| Peru | 12 | 29 | 3 | |
| **Africa** | **33 200** | **29 907** | **33 796** | **34 400** |
| Algeria | 858 | 946 | 893 | |
| Egypt | 720 | 708 | 647 | |
| Morocco/Sahara | 19 696 | 17 754 | 20 106 | |
| Senegal | 1 927 | 975 | 1 250 | |
| South Africa | 3 034 | 3 173 | 2 742 | |
| Togo | 2 244 | 2 035 | 2 081 | |
| Tanzania | - | - | 20 | |
| Tunisia | 4 596 | 4 196 | 5 924 | |
| Zimbabwe | 125 | 120 | 133 | |
| **Asia** | **21 408** | **23 251** | **25 077** | **27 000** |
| China | 10 862 | 11 728 | 12 500 | |
| Christmas Island | 1 423 | 1 328 | 1 095 | |
| India | 562 | 560 | 600 | |
| Iraq | - | 363 | 1 199 | |
| Israel | 2 373 | 2 711 | 2 969 | |
| Jordan | 4 244 | 4 431 | 4 749 | |
| North Korea | 500 | 500 | 500 | |
| Syria | 1 321 | 1 455 | 1 229 | |
| Vietnam | 110 | 160 | 220 | |
| Sri Lanka | 13 | 15 | 16 | |
| **Oceania** | **1 501** | **1 594** | **1 705** | **1 500** |
| Australia | 21 | 235 | 21 | |
| Nauru | 1 480 | 1 359 | 1 684 | |

Sources: Phosphate Rock Statistics, 1983, ISMA Ltd.; United States Bureau of Mines (USBM), Mineral Commodity Summaries 1984.
$^e$ Estimated.
Totals may not add due to rounding.

TABLE 6. PHOSPHATE, MAJOR NEW PROJECTS AND EXPANSION PROGRAMMES

| Company | Location | Design Production (ore, unless otherwise stated) | Completion Date | Capital ($ million) | Type of Operation | Remarks |
|---|---|---|---|---|---|---|
| **CANADA** | | | | | | |
| Sherritt Gordon | Kapuskasing, Ont. | 450 000 tpy phosphate | | | P/Cn | Evaluating Cargill property under option from IMCC. Partners being sought to fund acquisition of property and further development work. Feasibility of mining higher grade material at reduced rate under study. |
| New Ventures - Camchib Mines | Martison Lake, Ontario | Phosphate | late-1980s - early-1990s | | P/Cn | A high grade deposit with 57 million t grading 23% $P_2O_5$ plus niobium. Additional drilling and feasibility study in 1984. |
| **U.S.A.** | | | | | | |
| Amax Phosphate | De Soto/Manatee Co., Fla. | 3.6 million tpy phosphate | 1980s | 250 | P/Cn | Pine Level property development deferred. |
| C.F. Mining | Hardee Co., Fla. | 2 million tpy phosphate | 1985-86 | | P/Cn | Developments due on stream end of 1985. |
| Chevron | Vernal, Utah | 1.8 million tpy phosphate or less | 1986 | 250 | P/Cn | Expansion from 680 000 tpy to feed Rock Springs plant in Wyoming. Project downsized from $400 million. |
| Estech/Royster | Duette, Fla. | 2.7 million tpy phosphate | 1986 | 135 | P/Cn | Problems in obtaining Manatee County. |
| Grace/IMC | Hillsboro Co., Fla. | 5 million tpy phosphate | 1984-85 | 615 | P/Cn | Four Corners mine development in progress. Start in fiscal 1985. |
| Mobil Chemical | Ft. Meade, Fla. | 3.1 million tpy phosphate | late-1980s | | P/Cn | Dames & Moore study for new mine at South Ford Meade. |

TABLE 6. (cont'd)

| Company | Location | Design Production (ore, unless otherwise stated) | Completion Date | Capital ($ million) | Type of Operation | Remarks |
|---|---|---|---|---|---|---|
| NC Phosphate Corp. | Aurora, North Carolina | 3.6 million tpy phosphate | 1987 | 333 | P/Cn | Canvas Creek development by Agrico led j.v. |
| J.R. Simplot | Afton, Idaho | 2 million tpy phosphate | 1984 |  | P/Cn | New mine development at Smoky Canyon as replacement for the Conda mine. |
| **BRAZIL** |  |  |  |  |  |  |
| Industria de Fosfatados Catarinense | Anitapolis, Santa Catarina | 216 000 tpy $P_2O_5$ | 1985 | 170 | P/Cn | To supply ILM fertilizer plants. |
| Norfértil | Olinda, Pernambuco | 214 000 tpy phosphate (72% TCP) | 1985 | 53 | P/Cn | Feasibility studies completed. Run of mine capacity of 600 000 tpy. Reserves 20 million t. |
| **COLOMBIA** |  |  |  |  |  |  |
| IAN (Govt.) | Berlin, Caldas | U. Phosphate |  |  |  | Underground development work leading to prefeasibility study in collaboration with UNDP. |
| **MEXICO** |  |  |  |  |  |  |
| Rofomex | Bahia de Magdalena | 1.5 million tpy phosphate concs. |  |  | P/Cn | Production scheduled to start in the near future. |
| **PERU** |  |  |  |  |  |  |
| Probayovar | Bayovar, Piura | 3 million tpy phosphate | 1988-89 | 700 | P/Cn | Feasibility study completed by Jacobs. Investor interest now being sought. |

|  |  |  |  |  |  |
|---|---|---|---|---|---|
| **PACIFIC** |  |  |  |  |  |
| Raro Moana | Tumoto Is., French Polynesia | Phosphate |  |  | Sofremines feasibility studies on Maraiva deposit. |
| **BURUNDI** |  |  |  |  |  |
| Govt. | Matonga-Bandaga | Phosphate |  |  | British Sulphur Corp. prefeasibility study for World Bank completed end-1983. |
| **EGYPT** |  |  |  |  |  |
| El Nars Phosphate Co. | Sebaiya West | 770 000 tpy ore<br>440 000 tpy Phosphate concs. | 1984 | P/Cn | Mine expansion and 4 000 tpd beneficiation plant. Seltrust Engineering acting as purchasing agents and project managers for Abu Zaabel Fertilizer & Chemical Co. |
| Govt. | Abu Tartur, El Kharga | 2 million tpy phosphate concs. (28% $P_2O_5$) | 1988 | U | Experimental mine in operation, 2nd state expansion to 3.5 million tpy unlikely before 1985. |
| Misr Phosphate Co. | Hamrawein | 600 000 tpy phosphate concs. (33% $P_2O_5$) | 1986-87 |  | To increase production from present 180 000 tpy ore to 1.2 million tpy from ore (22% $P_2O_5$). |
| Red Sea Phosphate Co. | Abu Sheigela | 400 000 tpy phosphate concs. | 1985 | U/P | Replacing Quesir/Safaga mines. |
| **MALI** |  |  |  |  |  |
| Govt./BRGM | Tilemsi Valley | 240 000 tpy phosphate | 1980s | P | Feasibility study involving initial production of 20 000 t from Tamaguilelt section prepared. |
| **MAURITANIA** |  |  |  |  |  |
| SNIM/BRGM | Bofal | Phosphate |  | P | Prefeasibility studies in progress. |
| **MOROCCO** |  |  |  |  |  |
| OCP | Ben Guerir | 6 million tpy phosphate | 1989 | P | Doubling of capacity planned. |

TABLE 6. (cont'd)

| Company | Location | Design Production (ore, unless otherwise stated) | Completion Date | Capital ($ million) | Type of Operation | Remarks |
|---|---|---|---|---|---|---|
| OCP | Meskala, Essaouria | Phosphate | 1990 | | P/Cn | USSR assisted feasibility studies underway. |
| OCP | Recette IV, Mera El Ahrcch | 3 million tpy phosphate | 1984 | | P | Part of overall expansion of Khouribga mines from 18 million t to 24 million tpy by 1985-86. |
| OCP | sidi Hajaj | 3 million tpy phosphate | 1985 | | P/Cn | Beneficiation tests in progress. Ore will require flotation. To supply Jorf Lasfar complex. |
| OCP | Youssoufia | 8.4 million tpy phosphate | 1985 | | U/P/Cn | Underground mine expansion and calcination plant for "black phosphate". |
| **NIGER** | | | | | | |
| Govt. | Tapoa, Say | Phosphate | | | | Feasibility studies continuing on possible j.v., with Nigeria. |
| **SENEGAL** | | | | | | |
| Cie. Senegalaise de Phosphates de Taiba (CSPT) | Taiba | 2.1 million tpy phosphate | 1984 | | P | Expansion of capacity of Keur Mor Fall pit from 1.6 million tpy. |
| CSPT | Tobène | Phosphate | 1990s | | P | To be developed as replacement capacity for Keur Mor Fall. |
| **ISRAEL** | | | | | | |
| Negev Phosphates | Arad | 0.5 million tpy phosphate | 1984 | 35 | | Expansion of capacity as Makhtesh mine nears depletion. |
| **JORDAN** | | | | | | |
| Jordan Phosphate Mines Co. (JPMC) | Ruseifa, Al-Hasa, Wadi | Phosphate | 1980s | | P | Plans to increase production at existing operations by 50%. |
| JPMC | Shidiyeh, Aqaba | 10 million tpy phosphate | 1990 | | P | French consortium led by Sofremines studying project. Reserves 1 billion t. |

| | | | | | | |
|---|---|---|---|---|---|---|
| **PAKISTAN** | | | | | | |
| Sarhad Dev. Authority (SDA) | Hazara district, N.W. frontier province | 200 000 tpy phosphate | 1986 | 19 | P/Cn | British Mining Consultants have completed feasibility studies. |
| **PHILIPPINES** | | | | | | |
| Philphos | Isabel, Leyte | 100 000 tpy phosphate | 1984 | | P | Planning development of small phosphate mine to feed fertilizer complex. |
| **SRI LANKA** | | | | | | |
| State Mining Corp./ Agrico Chemical Co. | Eppawala | 585 000 tpy phosphate products | 1987 | 40 | P/Cn | Expansion from 150 000 tpy to feed TSP plant at Trincomalee (10%). Most of the rock will be exported. |
| **SYRIA** | | | | | | |
| General Co. for Phosphates & Mines | Gadir al Hamal | 5 million tpy phosphate | 1985 | | P/Cn | Expansion from present output level of 1.5 million tpy. |
| **TUNISIA** | | | | | | |
| Cie. des Phosphates de Gafsa (CPG) | Gafsa | 10 million tpy phosphate concs. | 1990 | | P/Cn | Tenders invited for feasiblity studies on development of reserves in the Oum el Kheceb and South Sehib areas. Includes 3 new mines -- Oum El Khjer, Kef Eddour and Jellabia-M'Zinda. |
| Soc. Phosphates de Sra Ouertane | Sra-Ouertane, Kef | 700 000 tpy phosphate concs. | 1987 | | P/Cn | Jacobs Engineering conducting feasibility studies on new development. Ultimately capacity to rise to 10 million tpy phosphate concs. by 2000. |

TABLE 6. (cont'd)

| Company | Location | Design Production (ore, unless otherwise stated) | Completion Date | Capital ($ million) | Type of Operation | Remarks |
|---|---|---|---|---|---|---|
| **TURKEY** | | | | | | |
| Etibank | Maziday | 250 000 tpy phosphate | 1985 | | P/Cn | Developing Semikan reserves. |
| **UGANDA** | | | | | | |
| Tororo Industrial Chemicals & Fertilizer Co. (Ticaf) | Sukulu, Sulukwe Hills | Phosphate | | | | Detailed engineering study being undertaken by Beardon Potter/SEMA (France) on development of phosphate project. |
| **UPPER VOLTA** | | | | | | |
| Buvogmi/CDF Engenierei | Abobo Djouna/ Kodjari | Phosphate | | | | Studies continuing with technical and financial support from the F.R.G. |
| **ZAMBIA** | | | | | | |
| Zimco | Kaluwe | Phosphate | | | | Feasibility studies and pilot plant testing by Serrana (Brazil) and Kemira Oy (Finland). Project not feasible economically but kept pending. |

Source: Mining Magazine, January 1984 with update by the Industrial Minerals Division, Energy Mines and Resources Canada.
P - Placer or opencast; U - Underground; Cn - Concentrator

**TABLE 7. LISTED EXPORT PRICES[1] FOR FLORIDA PHOSPHATE ROCK, 1982-84**

| Grade | January 1982 | Early[2] 1983 | Late 1984 |
|---|---|---|---|
| | ($US per tonne fob Tampa or Jacksonville) | | |
| 75% BPL | 57 | 35 | 39 |
| 72% BPL | 53 | 31 | 34 |
| 70% BPL | 50 | 29 | 31 |
| 68% BPL | 48 | 28 | 30 |
| 64% BPL | 46 | 26 | 25 |

Source: Phosphate Rock Export Association, Tampa, U.S.A.

[1] These prices do not include the charge for severance tax in Florida (i.e. $US 2.38 in 1984). [2] List prices for 1982 and early 1983 were not posted but indicative prices for the two periods are available.

# Platinum Metals

### G. BOKOVAY

For the lesser known platinum group metals (PGMs), osmium, rhodium, ruthenium and iridium, 1984 was a spectacular year as industrial and speculative demand pushed prices to new or near all-time highs. On the other hand, platinum prices declined throughout the year.

With the recovery of the U.S. economy, the strong U.S. dollar and the easing of inflation, platinum like gold, lost much of its attractiveness as an investment and speculative medium. Although industrial demand for platinum has been increasing, continuing surpluses of the metal have so far prevented a price recovery from occurring.

Palladium prices did appreciably better than those of platinum during 1983 and 1984, owing to a significant number of new applications and its increasing substitution for higher priced platinum and gold in other areas. However, with the significant erosion of palladium prices toward the end of 1984, this metal may have finally succumbed to the influence of weakening investor confidence that plagued some of the other precious metals.

Although the PGMs may have assumed some of the investment and speculative attributes of gold and silver, primary demand for these metals has and will remain dependant upon their industrial uses. Since the utilization of PGMs in existing industrial applications will likely increase substantially and that new uses will continue to be developed, the outlook for the platinum group is very positive. The prospects for platinum are somewhat less optimistic in view of the potentially fewer new applications for this metal and continuing substitution by palladium.

## CANADIAN DEVELOPMENTS

Platinum group metals are produced in Canada by Inco Limited and Falconbridge Limited as byproducts from the mining of nickel-copper ores. Although the bulk of the PGMs are recovered from operations in the Sudbury basin, small amounts of these metals are also produced by Inco at Thompson, Manitoba.

The residue from the refining of nickel-copper matte, which contains platinum group metals, is shipped by Inco to its refinery at Acton in the U.K. for the extraction and refining of PGMs. Falconbridge ships a nickel-copper matte containing PGMs to its refinery at Kristiansand, Norway.

Canadian production of PGMs in 1984 was estimated at 10 830 kg, of which 80 per cent was produced by Inco.

Canadian reserves of PGMs are estimated at about 280 million g of which 90 per cent are platinum and palladium in almost equal proportions.

Besides reserves associated with the nickel-copper ores of the Sudbury basin or Thompson, Boston Bay Mines has a PGM property in the Lac Des Iles area, near Thunder Bay, Ontario. The company has outlined two zones with an estimated average grade of 0.185 oz/st of PGMs plus recoverable values of copper, gold and nickel.

## WORLD DEVELOPMENTS

The major world producers of platinum group metals are the U.S.S.R., the Republic of South Africa and Canada. Minor producers include Japan - from imported nickel ores - Colombia, Finland, United States, Yugoslavia and Zimbabwe. Estimated 1984 world primary production of PGMs was about 213 million g which was about 6 per cent higher than in 1983.

The U.S.S.R., the largest producer of PGMs in the world, derives these metals principally as a byproduct of nickel-copper production. About half of Soviet output is exported to the west.

It is reported that about 85 to 90 per cent of Soviet production is produced from six mines in the Noril'sk region of Northern

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Siberia. The U.S. Bureau of Mines estimates that the PGM content of Noril'sk ores is as follows: 25 per cent platinum, 67 per cent palladium and the remaining 7 per cent composed of iridium, rhodium, ruthenium and osmium.

The other principal source of PGMs in the U.S.S.R., accounting for about 10 per cent of Soviet product, are found in the nickel-copper ores of mines in the Kola Pennisula in the northwestern part of the country. PGMs are also recovered from placer deposits in the southern Urals, once the major source of U.S.S.R. output.

In the Republic of South Africa, the world's second largest producer, there are three producers: Rustenburg Platinum Holdings Ltd., Impala Platinum Holdings Limited and Western Platinum Mines Limited. Unlike production in Canada or in the U.S.S.R., South African PGMs are derived from ores that are mined primarily for their platinum metal content. In addition, South African ores differ significantly from Soviet mineralization to the extent that they have a much higher ratio of platinum to palladium. The bulk of South Africa ores, which come from the Merensky Reef of the Bushveld Igneous Complex in the Transvaal, are thought to contain precious metals in the following proportion: 60 per cent platinum, 25 per cent palladium, 8 per cent other PGMs and 3 per cent gold. In addition, these ores also contain appreciable nickel and copper.

Rustenburg Platinum, the largest South African producer, has four active mining operations in the Merensky reef. The processing and refining of PGM concentrates and refinery residues is carried out at the Wadeville refinery at Gemistown in South Africa and another at Royston in the U.K. Both refineries are operated by the Matthey Rustenburg Refiners Group which is jointly owned by Rustenburg Platinum and the Johnson Matthey Group. A major fire at the Royston refinery on April 17, 1984 closed the plant until the end of June. However, with increased production at the Wadeville refinery in South Africa, overall production was reported to have been only minimally affected.

Matthey Rustenburg is considering the construction of a new PGM refinery in South Africa using a Solvex process that could significantly reduce refining expenses. An experimental Solvex refinery, which was opened at the Royston plant in 1983, was reported to be operating satisfactorily.

Rustenburg Platinum has the capacity to produce about 1 300 000 oz of platinum and 545 000 oz of palladium annually plus smaller quantities of the other PGMs. The company which was operating at about 65 per cent of capacity in 1983, was thought to be producing at significantly higher levels in 1984.

Impala Platinum, the second largest producer, has four active mining operations on the Merensky Reef. The company operates a base metal refinery at Springs, near Johannesburg, which processes matte containing nickel, copper and small quantities of PGMs. The PGM residue is also refined at Springs.

Impala's annual capacity is estimated at about 1 050 000 oz of platinum, 542 000 oz of palladium and 147 000 oz of ruthenium. At the beginning of 1984, the company was operating at about 70 to 75 per cent of capacity.

Western Platinum, the smallest producer in South Africa, operates one mine on the western limb of the Bushweld Complex. The company, which is owned by Lonrho S.A. Ltd., Falconbridge and Superior Oil Company, mines ore from both the Merensky and UG2 reefs in a ratio of about 2:1. Production by Western Platinum, which began in 1973, has been steadily increasing. For the fiscal year ending on Sept. 30/84, production of PGM in matte was 263 182 oz compared to 213 989 oz in fiscal year 1983.

Western Platinum ships matte to Falconbridge's refinery in Norway where nickel, copper and cobalt are extracted. The platinous sludge from this process is then returned to South Africa where platinum metals are extracted and refined at Lonrho's refinery at Brakpan. This facility is currently being expanded to handle rhodium, ruthenium and iridium. In addition, Western Platinum is proceeding with the construction of its own matte treatment plant in South Africa.

In the United States, test mining at PGM rich Stillwater Complex in Montana yielded positive results. Participants in the project, Chevron USA Inc., Anaconda Minerals Co. and Manville Corporation, were reported to be undertaking a feasibility study for full scale development. The project which could be in operation by late-1987, would have an annual output of 150 000 oz of palladium and 50 000 oz of platinum. A decision on whether or not to proceed is expected in the spring of 1985.

Although, European Economic Community members have so far been unable to agree on the timing of automobile emission regulations that would require PGM catalytic converters on vehicles, several related developments in Europe will undoubtedly boost demand for platinum metals used to manufacture automobile catalysts. Late in 1984, European Community ministers agreed to make lead free gasoline, which is used in automobiles with catalytic converters, available in all member countries by 1989. Earlier in the year, the Federal Republic of Germany announced that lead free gasoline would be available by 1986 and that road tax incentives will be in operation at the same time for cars fitted with pollution control catalysts. To stimulate the purchase of cars with catalysts, the price of non leaded fuel will be sold at a discount to other fuels.

### Recycling

It is estimated that about 10 per cent of the western world supply the platinum and 20 per cent of the palladium supply is derived from the recycling of industrial PGM scrap. Although the potential recovery of platinum metals from spent automotive catalysts could yield as much as 300 000 oz/y, the high cost of collecting and transporting catalysts or other scrap such as that generated by the electronics industry, to a processing facility have discouraged the necessary investment. In addition, falling prices for platinum, in particular, have discouraged secondary recovery.

## PRICES

### Platinum

Platinum prices like those of gold fell throughout 1983 and 1984 as investor interest decreased in the face of a strengthening U.S. dollar and diminishing rates of inflation. Although industrial demand has been increasing, increased consumption has failed to remove platinum surpluses from the market.

New York dealer prices for platinum which averaged $US 461 per oz in January 1983 fell to $374.50 in January 1984 and to $303.00 in December 1984. At the end of December, platinum was trading at $291.00 to $293.00.

### Palladium

Palladium prices rose throughout 1983 and into 1984 on the strength of growing industrial demand for the metal itself and as a substitute in many applications for higher priced precious metals. However, palladium prices which had risen from an average price of $US 125.10 per oz in January 1983 to an average price of $164.10 in December of 1983 fell substantially in the middle of 1984 and again at the end of the year. The average dealer price for December was $134.00.

### Other PGMs

Prices for rhodium, ruthenium, iridium and osmium rocketed upwards during 1984 due to strong speculative buying. This was fueled by good prospects for industrial demand in new and expanding applications, possible widening of U.S. stockpiling objectives and concerns over the supply adequacy of lesser known platinum group metals.

Unlike platinum and palladium which are at least principal products in the case of South African production, the other PGMs are all byproducts and as such, their supply is essentially inelastic.

Even in applications where overall PGM production might be stimulated, such as the three-way platinum/palladium/rhodium automotive catalysts being proposed for the European Community, the proportion of rhodium to platinum required for these products is considerably higher than that typically found in PGM ores.

During 1984, concern over the supply of the lesser PGMs was heightened by the labour unrest which was experienced by Impala Platinum early in the year and the major fire in April at Matthey Rustenburg's Royston refinery which was known to have affected the production of rhodium, iridium and ruthenium. In October reports of another fire at Englehard Corporation's refinery at Cinderford in the U.K. may have added to the speculation into the adequacy of PGM stocks.

Leading the price increases for the lesser PGMs was osmium, the rarest metal of the group, which increased from about $US 130 per oz in January 1984 to a trading range of $900-$1,000 per oz at the end of the year. Meanwhile, ruthenium increased from $US 25-27 in early January 1984 to $160-175 by year-end while rhodium increased from $US 265-270 to $890-910 during the same period. In addition, iridium increased from $US 285-305 to $460-475.

## USES

Platinum group metals are used in a wide variety of applications in pure form and in a host of alloys which require both the combination of different PGMs together or with other metals. The diversity of uses for these metals reflects their varied and unique attributes which include: chemical inertness and corrosion resistance, special magnetic properties, stable catalytic and thermoelectric properties, excellent reflectivity, stable electrical contact resistance and good high temperature oxidation resistance. The major uses of PGMs are in the automotive, jewelry, chemical, electrical, petroleum and glass industries.

One of the largest uses for PGMs, particularly platinum, is in the production of automobile catalysts. Although platinum is the principal PGM used in these catalysts, its importance in this application has been somewhat reduced owing to the substitution of lower priced palladium for at least some of the total PGM requirement. In addition to platinum and palladium, auto catalysts designed to control nitrous oxides as well as hydrocarbons contain rhodium. Depending on engine size, anywhere from 1.5 to 4.0 g of PGMs are contained in a single catalytic converter.

In addition to their use in controlling automobile exhausts, the production of lead free gasoline, which is required to avoid poisoning of auto catalysts, also uses PGM catalytic agents. Also in the refining industry PGM catalysts are used in hydrocracking and isomerization applications.

While the consumption of PGMs for automobile catalysts is largely in the United States, their use in jewelry, which constitutes the second largest use for platinum, is particularly large in Japan and has also been growing in the Federal Republic of Germany. Iridium and ruthenium are also widely used in jewelry.

In the chemical industry, PGMs are widely used as catalysts with the most important being platinum, ruthenium and palladium. Important specific applications include the production of nitric acid and hydrogen cyanide. It was reported that British Petroleum was developing a new ammonia production catalyst that uses ruthenium. The process is supposedly more efficient than the traditional one which uses an iron catalyst. PGMs are also used in the manufacture of equipment that is exposed to highly corrosive environments including anodes used in electrolytic manufacturing processes for such products as chlorine and caustic soda.

One of its major markets for palladium, is in the electronics industry where is is used in the manufacture of printed circuits, electrical contacts and electrical furnaces. In addition, PGMs and particularly palladium, are extensively used in the dental and medical field. The most important applications include dental alloys, orthodontic and prothodontic devices, hypodermic needles, electrodes, casings for pacemakers and as essential ingredients for certain chemotherapeutic agents used to treat certain cancers.

Other important applications for PGMs include: themocouples used for high temperature measurement; the manufacture of glass, glass fibre and synthetic fibres; fuel cells; permanent magnets; and catalytic applications in the pharmaceutical and food processing industries.

In addition to uses by industry or in the manufacture of jewelry, Rustenburg and Impala began in 1983 to market an array of platinum coins, wafers and small bars to stimulate investment demand.

## OUTLOOK

Within the next 12 to 18 months, it is expected that increasing industrial demand for platinum and palladium will cause prices for platinum and palladium to rise. Increased PGM production, particularly from South Africa, will likely result in some downward pressure on prices for other PGMs.

Consumption of the platinum group metals in the next decade is expected to increase at about 3 per cent per annum in view of an expected increase in the number of new applications and more widespread use of these metals in existing areas. Furthermore, demand should also be buoyed by continuing stockpiling activities by the U.S. government.

Assuming that the development of a clean-burn type of engine technology does not make PGM automotive catalysts obsolete, demand in this area is expected to remain strong in view of expected more widespread and stringent emission standards. These include the adoption of emission regulations in Australia in 1986, diesel engine standards which will take effect in North America in 1987 and probable European legislation which will take effect in the early-1990s. In the case of the latter, it is estimated that the European automobile catalyst market could require 500 000 to 700 000 oz/y of platinum.

Demand for palladium should continue to grow at a faster rate than platinum in view of the multitude of new applications particularly in the electronics industry for this metal, and also because of its increasing substitution for platinum and gold. As a result the price ratio between platinum and palladium which is presently about 2.4:1 could fall to about 2.0:1, even though South African production of palladium will increase as the more palladium rich UG2 reef begins to account for a larger share of production. This price ratio is supported by the fact that in the electronics industry, palladium is roughly half as efficient to use as platinum.

While the U.S.S.R. will remain an important supplier of PGMs, particularly palladium, to the west, its sales are expected to flatten out somewhat because of the probable increase in PGM consumption by Comecon countries and also due to an expected slower rate of growth in nickel production.

Canadian production of platinum metals is expected to increase somewhat in the next several years in response to higher nickel production levels.

Since it is considered that with existing recycling technology, it is uneconomic to recover PGMs when prices for platinum and palladium are below $US 300 and $150 respectively, little expansion of PGM recycling is expected in the short-term.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| CANADA | | | | | |
| 36300-1 | Platinum wire and platinum bars, strips, sheets or plates; platinum, palladium, iridium, osmium, ruthenium and rhodium, in lumps, ingots, powder, sponge or scrap | free | free | free | free |
| 48900-1 | Crucibles of platinum, rhodium and iridium and covers therefore | free | free | 15% | free |
| UNITED STATES (MFN) | | | | | |
| 601.39 | Precious metals ores | | free | | |
| 605.02 | Platinum metals, unwrought, not less than 90% platinum | | free | | |

| MFN Reductions under GATT<br>(effective January 1 of year given) | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | (per cent) | | | | |
| 605.03 | Other platinum metals, unwrought | 14.1 | 12.6 | 11.2 | 9.7 | 8.2 |
| 605.05 | Alloys of platinum, semi-manufactured, gold-plated | 17.5 | 15.6 | 13.8 | 11.9 | 10.0 |
| 605.06 | Alloys of platinum, semi-manufactured, silver-plated | 9.3 | 8.6 | 7.9 | 7.2 | 6.5 |
| 605.08 | Other platinum metals, semi-manufactured, including alloys of platinum | 14.1 | 12.6 | 11.2 | 9.7 | 8.2 |
| 644.60 | Platinum leaf | 14.1 | 12.6 | 11.2 | 9.7 | 8.2 |

Sources: The Customs Tariff and Commodities Index, January 1983. Revenue Canada; Tariff Schedules of the United States Annotated 1983, USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. PLATINUM METALS, PRODUCTION AND TRADE, 1982-84

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (grams) | ($) | (grams) | ($) | (grams) | ($) |
| **Production**[1] | | | | | | |
| Platinum, palladium, rhodium, ruthenium, iridium | 7 104 814 | 82,252,861 | 6 965 000 | 67,885,000 | 10 831 000 | .. |
| | | | | | (Jan.-Sept. 1984) | |
| **Exports** | | | | | | |
| Platinum metals in ores and concentrates | | | | | | |
| United Kingdom | 7 057 534 | 52,621,000 | 5 675 451 | 55,775,000 | 5 779 000 | 59,555,000 |
| United States | 104 352 | 882,000 | 81 243 | 834,000 | 31 000 | 515,000 |
| Total | 7 161 886 | 53,503,000 | 5 756 694 | 56,609,000 | 5 810 000 | 60,070,000 |
| Platinum metals, refined | | | | | | |
| United States | 519 273 | 4,591,000 | 2 471 140 | 31,479,000 | 3 040 000 | 27,399,000 |
| United Kingdom | 220 182 | 821,000 | 352 931 | 2,426,000 | 24 000 | 191,000 |
| Japan | 139 966 | 161,000 | 30 046 | 575,000 | - | - |
| Brazil | 1 182 | 22,000 | 17 107 | 292,000 | - | - |
| Other countries | 64 974 | 176,000 | 4 106 | 45,000 | 1 000 | 1,000 |
| Total | 945 577 | 5,771,000 | 2 875 330 | 34,817,000 | 3 065 000 | 27,591,000 |
| Platinum metals in scrap | | | | | | |
| United States | 1 148 000 | 14,925,000 | 906 169 | 11,728,000 | 1 478 000 | 24,717,000 |
| United Kingdom | 376 197 | 3,266,000 | 220 399 | 2,826,000 | 2 212 000 | 16,505,000 |
| West Germany | 61 772 | 200,000 | - | - | 420 000 | 5,478,000 |
| Total | 25 750 000 | 18,391,000 | 1 126 568 | 14,554,000 | 4 110 000 | 46,700,000 |
| **Re-export**[2] | | | | | | |
| Platinum metals, refined and semiprocessed | 8 242 | 170,000 | 276 000 | 4,384,000 | .. | .. |
| **Imports** | | | | | | |
| Platinum lumps, ingots, powder and sponge | | | | | | |
| United States | 139 966 | 2,010,000 | 24 416 | 418,000 | 118 000 | 1,903,000 |
| Switzerland | - | - | 17 511 | 265,000 | - | - |
| United Kingdom | 98 474 | 1,595,000 | 10 047 | 162,000 | 213 000 | 3,398,000 |
| Total | 238 440 | 3,605,000 | 51 974 | 845,000 | 331 000 | 5,301,000 |
| Other platinum group metals | | | | | | |
| United States | 183 106 | 602,000 | 347 768 | 1,902,000 | 186 000 | 1,546,000 |
| United Kingdom | 15 552 | 40,000 | 169 483 | 792,000 | 39 000 | 599,000 |
| West Germany | 24 883 | 76,000 | - | - | - | - |
| Total | 223 541 | 718,000 | 517 251 | 2,694,000 | 225 000 | 2,145,000 |
| Total platinum and platinum group metals | | | | | | |
| United States | 323 072 | 2,612,000 | 372 184 | 2,320,000 | 304 000 | 3,449,000 |
| United Kingdom | 114 026 | 1,635,000 | 179 530 | 954,000 | 252 000 | 3,997,000 |
| Switzerland | - | - | 17 511 | 265,000 | - | - |
| West Germany | 24 883 | 76,000 | - | - | - | - |
| Total | 461 981 | 4,323,000 | 569 225 | 3,539,000 | 556 000 | 7,446,000 |
| Platinum crucibles[3] | | | | | | |
| United States | 447 921 | 6,615,000 | 483 783 | 8,415,000 | 547 000 | 9,613,000 |
| West Germany | - | - | 218 | 4,000 | - | - |
| Total | 447 931 | 6,615,000 | 484 001 | 8,419,000 | 547 000 | 9,613,000 |
| Platinum metals, fabricated materials, not elsewhere specified | | | | | | |
| United Kingdom | 259 216 | 4,307,000 | 406 833 | 5,168,000 | 116 000 | 1,889,000 |
| United States | 521 045 | 3,518,000 | 724 182 | 2,976,000 | 471 000 | 2,119,000 |
| West Germany | 7 807 | 24,000 | 6 874 | 118,000 | 2 000 | 19,000 |
| Belgium-Luxembourg | 43 452 | 4,083,000 | - | - | - | - |
| Switzerland | 995 | 15,000 | - | - | - | - |
| Total | 832 515 | 11,947,000 | 1 137 889 | 8,262,000 | 589 000 | 4,027,000 |

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Platinum metal, content of concentrates, residues and matte shipped for export. [2] Platinum metals, refined and semiprocessed, imported and re-exported in the same form as when imported. [3] Includes spinners and bushings.

P Preliminary; - Nil; .. Not available.

## TABLE 2. CANADA, PLATINUM METALS, PRODUCTION AND TRADE, 1970, 1975 AND 1979-83

| | Production[1] | | Exports | | | | Imports[4] | |
|---|---|---|---|---|---|---|---|---|
| | | | Domestic[2] | | Re-exports[3] | | | |
| | (grams) | ($) | (grams) | ($) | (grams) | ($) | (grams) | ($) |
| 1970 | 15 005 188 | 43,556,597 | 15 327 731 | 44,174,000 | 634 480 | 2,365,735 | 1 889 381 | 3,123,000 |
| 1975 | 12 417 099 | 56,493,077 | 15 530 930 | 50,244,000 | 538 899 | 2,928,000 | 1 896 410 | 6,061,000 |
| 1979 | 6 156 716 | 56,333,561 | 6 641 432 | 54,686,000 | 43 172 | 359,000 | 826 886 | 6,546,000 |
| 1980 | 12 776 000 | 159,088,000 | 13 524 725 | 191,569,000 | 9 176 | 68,000 | 1 064 578 | 14,347,000 |
| 1981 | 11 902 283 | 136,186,021 | 11 094 424 | 110,838,000 | 498 | 10,000 | 687 604 | 8,573,000 |
| 1982 | 7 104 814 | 82,252,861 | 8 107 463 | 59,274,000 | 8 242 | 170,000 | 461 981 | 4,323,000 |
| 1983P | 5 195 000 | 67,885,000 | 8 632 024 | 91,426,000 | .276 000 | 4,384,000 | 569 225 | 3,539,000 |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Platinum metals, content of concentrates, residues and matte shipped for export. [2] Platinum metals in ores and concentrates and platinum metals, refined. [3] Platinum metals, refined and semiprocessed, imported and re-exported. [4] Imports, mainly from United States and United Kingdom, of refined and semiprocessed platinum metals, derived from Canadian concentrates and residues, a large part of which is re-exported.
P Preliminary.

## TABLE 3. WORLD MINE PRODUCTION OF PLATINUM METALS, 1981-84

| | 1981 | 1982 | 1983e | 1984e |
|---|---|---|---|---|
| | (grams) | | | |
| U.S.S.R.e | 104 196 647 | 108 862 169 | 111 973 000 | 111 973 000 |
| Republic of South Africae | 96 731 813 | 80 869 040 | 80 869 000 | 87 090 000 |
| Canada | 11 902 283 | 9 104 814 | 6 965 000 | 10 831 000 |
| Japan | 1 128 092 | 1 345 941 | .. | .. |
| Colombia | 460 363 | 373 242 | .. | .. |
| Australia | 470 347 | 436 382 | .. | .. |
| United States | 227 615 | 249 854 | 249 000 | .. |
| Other countries | 227 895 | 224 101 | 2 177 000 | 2 756 000 |
| Total | 215 345 055 | 199 465 543 | 202 233 000 | 212 650 000 |

Sources: U.S. Bureau of Mines, and Energy, Mines and Resources, Canada.
e Estimated; .. Not available but included in "other".

# Potash

## G.S. BARRY

Production and shipments of potash to all markets in 1983 and 1984 were much higher than in the depressed year of 1982. Production was up 13.6 and 26.5 per cent for 1983 and 1984 respectively and shipments were up 28.5 and 10.8 per cent for 1983 and 1984. The volume of shipments was particularly strong in the second half of 1983; was steady but much below expectations in the first half of 1984; was strong again in the third quarter of 1984 but failed to follow through in the last quarter of 1984. The surge in offshore demand however was steady whereas North American sales showed wide fluctuations.

Producers started 1983 with high stocks (1 486 200 t $K_2O$) and were carrying this high inventory until July, since the universally expected pick-up in spring sales did not materialize. Those initial conditions necessitated some cutbacks in production during January and February and the summer months. An unexpected boost in sales for the last five months of 1983 resulted in a rapid reduction of inventories to 861 500 t $K_2O$. In 1984 inventories increased again to end the year at about 1 570 000 t.

The reported average price received for potash in 1983 by Canadian producers was $Cdn. 102.60 per t $K_2O$ compared to $Cdn. 118.78 in 1982 and $Cdn. 151.25 in 1981. The price received in 1984 was estimated at $Cdn. 108.90 per t $K_2O$.

Employment in the Saskatchewan potash mining industry was 3,697 in 1983 compared to 4,075 in 1982. There was not much change in 1984. In addition up to 300 were employed on contract at an expansion project. In New Brunswick employment was about 260 at the operating mine and rose from 170 in 1983 to just over 600 in 1984, mainly contracted, at the mine under construction.

### DOMESTIC DEVELOPMENTS

At the end of 1983, Canadian installed potash production capacity was 9 160 000 t in Saskatchewan and a nominal 100 000 t in New Brunswick. The largest share of capacity, 41.7 per cent, is held by Potash Corporation of Saskatchewan (PCS), a provincial Crown corporation, followed by 20.2 per cent for International Minerals & Chemical Corporation (IMC) the largest private producer in the western world.

PCS curtailed all new expansions but continued with its major expansion program at the Lanigan mine which was 63 per cent completed by the end of 1983 and 80 per cent completed by the end of 1984 with a target for total completion in 1986. To date over $350 million has been expended against a total estimate of $475 million. Capacity of the Lanigan mine will be 1 740 000 t $K_2O$. PCS introduced at Lanigan the world's largest underground continuous mining machine. It is known as the "Orebiter". It combines the high productivity of a four-rotor borer (lower part) with the flexibility of a boom-type miner with two cutting heads mounted on top. The Orebiter cuts an opening averaging 5.2 by 8.0 m at one pass; weighs 364 t and has a rated capacity of 1 000 t per hour. During 1983, PCS instituted in all of its mines, except one, a working schedule of 10 days for every 14-day period for underground mining, thus reducing by 1 shift the traditional 4 shifts per week working schedule. The surface plants remained on a continuous schedule. The Lanigan, Cory, Rocanville and Allan mines were not producing in January and February and for about half a month each either in July or August 1983. In 1984 PCS mines were closed for short maintenance periods during July or August and for Christmas week. An inflow of water occurred in November 1984 at the Rocanville mine. At the end of December the situation was under control but still serious. A primary plug was being installed at the affected entry and drilling was in progress to permit supplementary grouting from the surface. The mine was closed for production a few days before Christmas and is expected to reopen as soon as the plug installation is completed. PCS announced that it will construct a "demonstration plant" to

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produce 30 000 tpy of potassium sulphate at its Cory division. The plant is expected to be in production in 1985 and the capital expenditures will be in excess of $6 million. The potassium sulphate will be produced through a chemical reaction of sodium sulphate and potassium chloride (Glaserite process). Natural sodium sulphate is also abundant in Saskatchewan.

The International Minerals & Chemical Corporation reduced production for two months early in 1983 and for two short intervals in mid-year at its K1 and K2 mines, but for the last four months the company operated at full capacity. In 1984 the company produced near normal levels, shutting the mine for a two week maintenance period in June-July. The company announced that a potash production expansion remains on hold until there is clear evidence of a long-term improvement in market.

Cominco Ltd. produced 620 000 t $K_2O$ (1 018 000 t KCl) during 1983, but had to close its mine at mid-year for nine weeks, six for inventory control and three for maintenance. In 1984, the company produced 1 235 000 t (KCl). It closed the plant in July for three weeks for normal maintenance. Central Canada Potash, a subsidiary of Noranda Inc., closed its mine for three months from July to September 1983. During 1984 the mine was closed from July 14 to September 6 and for the Christmas week. The company produced 970 000 t (KCl) in 1983 and 1 074 000 t (KCl) in 1984. The company is currently re-examining its options for expanding capacity in the late-1980s. Potash Corporation of Saskatchewan, a subsidiary of Ideal Basic Industries, Inc. produced 682 000 t of muriate of potash (KCl) in 1983. The company closed its mine for the month of September. Kalium Chemicals, a division of PPG Canada Inc., continued to operate at below recently expanded capacity levels for the first nine months of 1983, thereafter operating at full capacity. Kalium began work on expanding its capacity at the Belle Plaine mine from 1 055 000 t to 1 320 000 t $K_2O$ at a cost of $100 million. Completion is scheduled for the end of 1986. During expansion, improvements to the process will be carried out principally raising energy efficiency, returning a larger proportion of waste salt to underground cavities and the installation of compaction machines. The company established a 41 700 t storage depot in Toledo, Ohio, and is building another facility in Madison, Wisconsin.

For the period in effect from July 1st, 1979 to June 30, 1984 the Saskatchewan potash producer paid resource revenues to the province under separate but similar agreements known as the "Potash Resource Payment Agreement" (PRPA). The payment system was described in detail in the 1980 potash review. The private potash companies felt that the provisions of these agreements require some improvements and hoped to negociate a better five-year term with the new provincial government. However, following extensive negociations during 1984, the government decided to extend the previous agreement for six months to the end of 1984, at which time a further extension could be considered if necessary. During the past five-year PRPA the province of Saskatchewan collected approximately $700 million from the potash industry.

In Manitoba, two concession areas are potential sites for future potash mines. IMC suspended further planning and consultations with the provincial government on their site until market conditions improve. Meanwhile on the second site, Canamax Resources Inc., a subsidiary of AMAX Inc., and the Manitoba Government commissioned a feasibility study to be completed by the end of June 1985 for a 1.8 million tpy (KCl) potash mine. Reserves are approximately 440 million t grading better than 25 per cent $K_2O$. If a positive decision is made a mine with a capacity of about 1.2 million tpy $K_2O$ could be in production in the early-1990s. Costs of construction in 1984 dollars would be in excess of $500 million.

In New Brunswick, the Potash Company of America (PCA) commenced production and plant tune-up at its new mine near Sussex in August 1983. Later in that year, product was railed to the company's port storage facilities at Saint John and the first shipment to Europe was made in January 1984. The company experienced some start-up difficulties which were partially remedied during 1984. Evaporator capacity was increased, and modifications were carried out on the continuous miners and the conveyor system. Full production capability is targeted for mid-1985. Shipments of byproduct salt to International Salt Co. (N.Y.) which took place intermittently during the development stage were resumed. PCA intends to mine approximately 440 000 tpy of commercial common salt. Capital expenditures for the PCA mine were approximately $225 million. Port facilities at Saint John were $40 million of which the company paid half. The PCA mine was designed for a capacity of

545 000 tpy $K_2O$ but will be operated at a reduced nominal base of 380 000 tpy $K_2O$ for at least the first two full years of production. The upgrading of capacity in response to market conditions can be accomplished rapidly.

The Denison-Potacan Potash Company announced in February 1983 that it will proceed to bring into production its Clover Leaf mine near Salt Springs by late-1985. Reserves at this location are 254 million t of high-grade ore of which 45 million t grading 28.5 per cent $K_2O$ was outlined through underground exploration. The nameplate capacity of the mine will be 780 000 tpy. The first shaft at the mine was completed in 1982 and the second production shaft was started in March 1983 and will be completed in mid-1985. All work at the development site is slightly ahead of schedule. Capital expenditures for the project are estimated at above $300 million.

The British Petroleum Company Limited (BP) completed a drilling program on its Millstream concession near Sussex in 1983. The company encountered beds of potash at depths between 950 and 1 050 m. Tonnage and grade indications on two mineable beds are very encouraging. In 1984, a pilot hole for a shaft was completed without encountering any problems. In early-1985 BP is expected to apply for a mining licence which will permit a decision on sinking an exploration shaft. There is a possibility that production on this site, the third potash basin in New Brunswick, will start sometime in the 1990s.

Potash bearing intersection were also reported in Nova Scotia where two companies did some limited drilling in the Bras d'Or lake area. There are also some indications of potash presence in the saline formations along the west coast of Newfoundland and on the Madeleine Islands of Quebec.

## INTERNATIONAL DEVELOPMENT

For 1983 the United States Bureau of Mines estimates world potash production at 26.7 million t $K_2O$ which includes a sales level for Canada of 6.2 million t as a proxy for production. The International Fertilizer Association (IFA) estimates world production at 26.2 million t which includes a high estimate of 9.3 million t for the U.S.S.R. Energy Mines and Resources Canada estimates world 1983 production at only 25.3 million t allowing for 5.9 million t in Canada and only 8.4 million t in the U.S.S.R.

World production in 1984 is estimated at 28 500 000 t, a 13 per cent increase over 1983. Production in the U.S.S.R. is estimated at 9 million t. Canada and the U.S.S.R. contributed most to this increase.

Brazil - PETROBRAS Mineracao S.A. awarded a contract for the potash handling system to a firm in the Federal Republic of Germany. The mine has a projected 500 000 tpy KCl capacity and will achieve commercial production in 1985 or 1986. Petromisa holds another interesting potash deposit near Fazendinha in the Amazonian basin. During 1984 the company awarded a $700,000 feasibility study to a joint venture consisting of Paulo Abib Engenharia, Mines de Potasse d'Alsace and Patrick Harrison and Company Ltd., a Canadian firm. Petromisa estimated reserves of 525 million t at an average depth of 1 050 m.

Chile - Corporacion de Fomento de la Production asked for bids for the development of potash in the Salar de Atacama. Preliminary studies indicated the potential for a production of 500 000 tpy of KCl and 150 000 tpy of sulphate of potash with the aid of solar evaporation. A provisional award was made to Amax Chemical Corporation. Its final acceptance involves the exploitation of lithium. It is estimated that the exploration phase of the potash project will take three years.

China - Jacobs International of Ireland completed a feasibility study for a 200 000 tpy KCl potash plant at the dry salt Chaerhan Lake in western China. Another project for a 1 million tpy plant 200 km to the west of the first location is also under consideration. The region requires considerable infrastructure and costs of production will be high. The development is not likely to occur before the end of this decade.

Ethiopia - A two-year feasibility study on potash production in the Danakil Depression was started by Entreprise Minière et Chimique for the Ethiopian-Libyan Mining Co. The region produced some carnallite before the Second World War. In 1965 and 1966 a shaft was sunk at Musley into sylvinite beds by the Ralph M. Parsons Company of the United States but the 500 000 tpy project was abandoned in 1968.

France - In October 1983 the French Assembly approved the Rhine Treaty which limits the disposal of waste salt tailings into the Rhine, currently amounting to between 6 and 7 million tpy. Measures to this effect will be implemented within 18 months. Well tests for deep subsurface brine disposal were conducted near Reiningue but commercial injection is being delayed by protests from local residents. The Theodore mine of Mines de Potasse d'Alsace (MPDA) will be closed in 1985 or 1986. The Amelie surface plant will be converted from the dissolution-recrystallization process to flotation at a cost of $Cdn. 50 million. An additional $75 million will be spent on other MPDA's modernization programs.

Germany, Federal Republic of - The Friedrichshall Potash Works mine, purchased from Kali-Chemie A.G. by Kali & Salz A.G. in 1981 was joined up underground to the Bergmannssegen-Hugo Potash Works mine. Surface operations at Friedrichshall were then closed and Bergmannssegen-Hugo facilities will serve the output of both mines. The Siefried-Giesen Potash Works mine ceased production of muriate of potash but will continue the output of kainite ore. Production at Kali und Salz in 1984 was back to normal levels of 2.6 to 2.7 million t $K_2O$.

Israel - In early 1984 the Dead Sea Works Ltd. completed its expansion program at Sodom and now has a capacity of 2.1 million tpy of muriate of potash equivalent to 1.28 million tpy of $K_2O$. The DSW units comprise 250 000 tpy of flotation product, 1 million tpy from the hot leach plant and two cold leach units of 450 000 tpy each. Production at the very high cost flotation plant will be reduced once the cold leach plant is in full operation. DSW transports most of its product by trucks and train to the port of Ashdod and some through the port of Eilat on the Red Sea. Between 1984 and 1987 the company will construct a conveyor belt from Sodom to Nahal Zin that will link to existing rail and replace costly truck haulage on steep grades.

Jordan - After the completion of the Arab Potash Co. Ltd. (APC) 1.2 million tpy KCl plant on the Dead Sea in 1982 output rose more slowly than originally anticipated. The current estimates are: 260 000 t in 1983, 500 000 t in 1984, 700 000 t in 1985, and full production expected by 1987. However, APC has to make a major additional investment on the addition of a fourth carnallite pan (C4) before the envisaged capacity is reached. Without C4 maximum capacity would be 1.1 million tpy.

Mexico - Fertilazantes Mexicanos SA has reactivated its potash project at Cerro Prieto near Mexicali on the California border. The extraction will be from brines, using as energy geothermal steam available nearby. The projected capacity is 80 000 tpy KCl to be completed by late-1986 or early-1987. A byproduct capacity of 125 000 tpy of common salt and 81 000 tpy of calcium chloride is also envisaged.

Spain - The Spanish potash industry is undergoing major reorganization. Instituto Nacional de Industria (INI) announced that it will close its subsidiary Potassas de Navarra SA in December 1985. This company currently operates a mine near Pamplona which has a theoretical capacity of 325 000 tpy $K_2O$ but recently operated at only half this level. The deposit is low-grade (12 per cent $K_2O$) and structurally complex. INI acquired a 51 per cent interest in Minas de Potasas de Suria S.A. from Solvay & Cie in 1982 with the option to buy the remaining 49 per cent share. The company plans to expand capacity by 50 000 tpy $K_2O$ to 220 000 tpy $K_2O$ at the Suria mine by 1986. As the mining will be concentrated in the Catalonia district, there is a possibility of opening a new mine between Suria and Llobregat in the more distant future. Explosivos Rio Tinto (ERT) also plans to substantially increase investments in its Cordona and Llobregat mines so that by the end of this decade a substantial part of the lost capacity will be restored.

Thailand - Thailand has two potash bearing saline basins, the Khorat and the Sakhon-Nakhon basins. The Department of Mineral Resources (DMR) started a pilot project in 1982 to demonstrate the feasibility of carnallite exploitation near Chaiyaphum in the Khorat Basin. An inclined access drift was sunk but had to be abandoned because of high water inflow in 1983 after the expenditure of $5 million. The total project budget was $11.1 million of which $8.9 is a World Bank loan. DMR is considering the option of starting at a new site, 10 km away by sinking a vertical shaft to reach the potash horizon at about 150 m below surface, but a positive decision is not likely. Negotiations were meanwhile concluded for the exploration on a 3 500 square km potash concession in the Sakhon-Nakhon basin, in the province of Khon Kaen, between DMR and joint venture partners, Duval Corporation of USA (Pennzoil Company), CRA Exploration Pty Ltd. of Australia and Siam Cement of Thailand. The operating company will be Thai Potash Co. Ltd. Success could lead to development of a mine at a cost in excess of $350 million. In October 1984, the Thai government signed another agreement with the Thai Agrico Potash Co. Ltd. for a 2 333 square km concession in the Udon Thani province, 450 km northeast of Bangkok. The company is committed to spend a minimum of $US 3 million over five years on potash exploration. The Thai deposits present a geological challenge since the disposition of sylvinite ore in predominantly carnallitic potash is generally discontinuous.

Tunisia - The World Bank is making a $13.6 million loan to Tunisia for studies in the phosphate industry and a study on the feasibility of extracting potash from underground brines in the Sabkha el Melah depression near the new port of Zarzis. French companies will carry out the survey.

United States - Production in 1983 declined by 20 per cent to 1.4 million t $K_2O$, the lowest level since 1951, but rebounded to an estimated level of 1.6 million t in 1984. About 85 per cent of production comes from six underground mines in New Mexico where the average content of ore mined is 12.9 per cent $K_20$ compared to 24.8 per cent $K_2O$ in Canada. The remaining production is from a solution mine in Utah and brines in Utah and California. On January 19, 1983, Mississippi Chemical Corporation shut down its potash mine near Carlsbad, N.M. for an indefinite period which may in fact become a permanent closure. This brings down New Mexico mines number to five. During the year, some New Mexico mines were shut during the July to September period to reduce excessive inventories.

The two brine potash producers in Utah experienced production difficulties related to severe weather conditions and flooding. Kaiser Aluminum & Chemical Corporation, Chemicals division, had to shut down its plant for one year starting September 30, 1983. Great Salt Lake Minerals & Chemicals Corp. lost its brine evaporation ponds and will take up to three years to complete the recovery of these facilities.

PPG Canada Inc. completed a drilling program on deep potash-bearing salt formations in Mecosta County, central Michigan. The company is currently constructing a test facility employing similar solution mining techniques as at Belle Plaine, Saskatchewan. The Michigan deposits are at a depth of some 3 km or less compared to 2 km or less in Saskatchewan.

In California, Kerr-McGee Chemical Corporation continued to produce muriate and sulphate of potash after only a short interruption of about three months when the company announced and then rescinded a decision to permanently suspend the production of its main product - muriate of potash.

On March 30, 1984, Amax Chemical Inc. and the Kerr-McGee Chemical Corporation filed a petition with the International Trade Commission (ITC) alleging that subsidized producers in Israel, the German Democratic Republic, Spain and the U.S.S.R. are dumping potash in the United States. These allegations were two-pronged; countervailing duties (CVD) were sought on account of subsidies and ad valorem duties (A/D) were sought for dumping. In May, ITC issued a preliminary ruling in favour of the plaintiffs. However, the CVD action against the U.S.S.R. and GDR was dismissed by the Department of Commerce on grounds that bounties or grants within the meaning of Section 303 of the tariff act of 1930 cannot be found in non-market economies. A net subsidy of 7.54 per cent for Spain and 8.71 per cent for Israel were preliminary determinants in June; these CVD were subsequently reduced and finally dropped when on October 22, 1984, ITC ruled no injury. On the A/D action the Department of Commerce found dumping margins of 187.03 per cent for the U.S.S.R.; 112.12 per cent for GDR; 43.65 per cent for Spain; and minimal for Israel. The final determinations for dumping on potash from U.S.S.R., GDR and Spain were scheduled for the first week of January 1985, but the U.S.S.R. and GDR were granted 60-day extensions.

U.S.S.R. - During 1983 U.S.S.R. potash exports declined by 18 per cent to 2.3 million t $K_2O$. There was a substantial decline of 33 per cent in exports to East European countries and a 15 per cent increase to the rest of the world. There are indications that there was a substantial increase in domestic demand, perhaps approaching 5.6 million t which may include some increase in inventories. Nevertheless, U.S.S.R.'s production in 1983 could not have been much higher than 8.4 million t $K_20$, much below the 9.3 million t estimated by IFA. This suggested 8.4 million estimate of 1983 production will also allow for a "loss" of about 0.5 million t or 6.3 per cent of production. Such a "loss" is compatible with the average "loss" of 5.7 per cent computed for the U.S.S.R. for 1970-82 period.

During 1983, production started at two units of the Novosolikamsk mine in the Urals. This mine was originally scheduled to start in 1980 but ran into many difficulties, in particular with the operation of oversize crystallizers. The originally targeted capacity for Novosolikamsk was 2.9 million t $K_2O$ but it had to be substantially downsized, apparently to about 1.6 million t $K_2O$ with three units of 900 000 tpy KCl each (540 000 tpy $K_2O$). The third unit will be completed under the 1985-90 five-year development plan. Another source reports that each unit at the Novosolikamsk plant has a capacity of only 375 000 tpy $K_2O$ rather than 540 000 t.

In September 1983, an earth dam burst near the Stebnik potash mine in the Ukraine, releasing brines to the Dniester river and causing widespread ecological damage. The Byeloruskali complex will add a 50 000 tpy potassium sulphate plant to be completed in 1987 or 1988. A plant in the same location based on the glaserite process is apparently not in operation. The U.S.S.R. reported the successful pilot plant testing of solution mining at Karlyuk, Turkmen S.S.R. and intends to construct a full scale 700 000 tpy KCl solution mine.

The U.S.S.R. and GDR together currently export two-thirds of their excess potash to COMECON countries and the remainder to the rest of the world. By 1988, these two countries are expected to consume internally 7.5 million t $K_2O$; export to other COMECON countries 4.0 million t and have available for export to the rest of the world about 2.6 to 2.7 million t. This level of 'outside' exports is most likely going to be maintained for a few years.

United Kingdom - Cleveland Potash Ltd. continued to improve productivity at its Boulby mine operating at an effective capacity of 300 000 tpy $K_2O$. A new tunnel and conveying system between the working panels and the shaft was installed in massive salt below the potash zone. The company is also doubling the compaction facility from 120 000 tpy to 240 000 tpy at a cost of $1.5 million. Another $800,000 will be invested to recover potash from brines at an initial pilot stage of 9 000 tpy, which could be eventually expanded to 27 000 tpy. The new prototype plant will involve a refrigeration technique whereby potash crystals will be separated from the frozen brine.

## PRICES

Typical contract prices for Canadian potash (standard grade) moving out of Vancouver were $75 to $77/t KCl at the beginning of 1983; $73 to $75/t in mid-year and edged upward to $78-$81/t at the end of the year. Prices negotiated for the first half of 1984 were in the low eighties. Despite sales on good volume the prices weakened by mid-1983. Expected strong domestic sales for the fall of 1984 did not materialize and the prices in North America were still very weak at the end of the year when standard grade was quoted at $50/t fob mine. An increase is expected by March 1985.

## OUTLOOK

Good recovery in the second half of 1983 allowed for a substantial reduction of inventories but was not accompanied by a sustained price rise. Slower than expected 1984 spring sales in North America put a damper on the expansion, but further gains in sales are expected in 1985 with continuing price recovery.

For 1986 to 1987 adequate supply of potash should be the rule rather than the exception and prices will remain firm. Thereafter new sources of supply should be fairly well in step with rising demand and chances of another period of expansion to overcapacity levels remain remote until the end of the 1980s. In the early 1990s producers and prospective producers in all provinces should aim at coordinated, timely developments since the penalty for a misjudgement in world capacity requirements could be very onerous.

TABLE 1. CANADA, POTASH PRODUCTION, SHIPMENTS AND TRADE, 1982-84

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($) | (tonnes) | ($) | (tonnes) | ($) |
| **Production,** potassium chloride | | | | | | |
| Gross weight | 8 750 493 | .. | 9 703 531 | .. | 12 275 000 | .. |
| $K_2O$ equivalent | 5 351 786 | .. | 5 929 567 | .. | 7 500 000 | .. |
| **Shipments** | | | | | | |
| $K_2O$ equivalent | 5 308 532 | 630,561,741 | 6 293 747 | 645,767,272 | 6 972 407 | 759,270,149 |
| | | | | | (Jan.-Sept. 1984) | |
| **Imports,** fertilizer potash | | | | | | |
| Potassium chloride | | | | | | |
| United States | 1 878 | 682,000 | 2 270 | 1,205,000 | 1 605 | 767,000 |
| United Kingdom | 3 | 2,000 | 7 | 2,000 | 4 | 1,000 |
| Total | 1 881 | 684,000 | 2 277 | 1,207,000 | 1 609 | 768,000 |
| Potassium sulphate | | | | | | |
| United States | 20 045 | 3,524,000 | 15 411 | 3,297,000 | 2 201 | 628,000 |
| Potassic fertilizer, nes | | | | | | |
| United States | 57 650 | 6,258,000 | 47 367 | 6,257,000 | 7 650 | 1,344,000 |
| Potash chemicals | | | | | | |
| Potassium carbonate | 1 113 | 728,000 | 1 555 | 904,000 | 1 529 | 908,000 |
| Potassium hydroxide | 3 407 | 1,776,000 | 2 936 | 1,990,000 | 1 811 | 1,339,000 |
| Potassium nitrate | 2 444 | 1,096,000 | 4 343 | 1,869,000 | 2 653 | 1,295,000 |
| Potassium phosphate | 1 492 | 1,566,000 | 1 729 | 2,190,000 | 1 503 | 2,068,000 |
| Potassium silicates | 686 | 617,000 | 813 | 621,000 | 535 | 458,000 |
| Total potash chemicals | 9 142 | 5,783,000 | 11 376 | 7,574,000 | 8 031 | 6,068,000 |
| **Exports,** fertilizer potash | | | | | | |
| Potassium chloride, muriate | | | | | | |
| United States | 4 741 203 | 452,572,000 | 5 656 827 | 481,183,000 | 4 835 000 | 459,880,000 |
| Japan | 536 244 | 55,591,000 | 869 316 | 96,032,000 | 533 606 | 64,625,000 |
| India | 447 700 | 44,152,000 | 428 242 | 47,525,000 | 500 270 | 60,917,000 |
| Brazil | 211 808 | 21,789,000 | 287 419 | 34,249,000 | 423 916 | 52,325,000 |
| People's Republic of China | 66 660 | 7,818,000 | 536 539 | 59,420,000 | 403 510 | 49,444,000 |
| South Korea | 309 031 | 30,467,000 | 323 236 | 35,897,000 | 308 729 | 37,708,000 |
| Australia | 204 912 | 21,419,000 | 197 214 | 21,894,000 | 201 198 | 24,626,000 |
| Singapore | 228 291 | 22,602,000 | 118 260 | 13,128,000 | 144 433 | 17,549,000 |
| France | - | - | 48 790 | 5,118,000 | 131 121 | 11,815,000 |
| Malaysia | 12 185 | 1,186,000 | 37 352 | 4,131,000 | 96 730 | 12,067,000 |
| Indonesia | 128 883 | 12,788,000 | 16 480 | 1,853,000 | 94 151 | 11,277,000 |
| Taiwan | 64 040 | 6,347,000 | 86 227 | 9,538,000 | 80 851 | 9,723,000 |
| Other countries | 270 536 | 28,044,000 | 357 932 | 40,084,000 | 461 222 | 77,995,000 |
| Total | 7 221 493 | 704,775,000 | 8 963 834 | 850,052,000 | 8 214 829 | 854,792,000 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; - Nil; .. Not available; nes Not elsewhere specified.

## TABLE 2. CANADA, POTASH PRODUCTION AND SALES BY GRADE[1] AND DESTINATION, 1982 AND 1983

| | 1983 | | | | | | 1982 |
|---|---|---|---|---|---|---|---|
| | Standard[2] | Coarse | Granular | Soluble | Chemical[3] | Total | Total |
| | (tonnes $K_2O$ equivalent) | | | | | | |
| **Production** | 1 509 928 | 2 239 121 | 1 498 848 | 624 619 | 55 885 | 5 928 401 | 5 207 878 |
| **Sales** | | | | | | | |
| Canada | 14 238 | 273 420 | 87 045 | 10 201 | .. | 384 904 | 272 799 |
| United States | 286 356 | 2 197 484 | 1 138 910 | 523 100 | .. | 4 145 850 | 3 202 377 |
| Offshore | | | | | | | |
| Argentina | - | - | - | 68 | .. | 68 | - |
| Australia | 3 650 | 83 552 | 41 637 | - | .. | 128 839 | 120 598 |
| Bangladesh | 49 898 | - | - | - | .. | 49 898 | 23 145 |
| Belgium | 29 846 | - | 6 584 | - | .. | 36 430 | 12 721 |
| Brazil | 52 227 | 25 320 | 137 075 | - | .. | 214 622 | 128 945 |
| Chile | 24 434 | - | - | 6 847 | .. | 31 281 | 19 646 |
| China | 446 297 | - | - | - | .. | 446 297 | 140 855 |
| Costa Rica | 6 665 | 1 822 | - | - | .. | 8 487 | - |
| France | 15 090 | - | - | - | .. | 15 090 | - |
| India | 277 085 | - | - | - | .. | 277 085 | 223 816 |
| Indonesia | 6 231 | - | - | - | .. | 6 231 | 59 148 |
| Ireland | - | - | 15 323 | - | .. | 15 323 | - |
| Italy | - | - | - | 8 911 | .. | 8 911 | - |
| Jamaica | - | 2 585 | - | - | .. | 2 585 | - |
| Japan | 131 260 | 72 970 | 37 608 | 106 402 | .. | 348 240 | 346 107 |
| Korea | 182 023 | - | - | 8 711 | .. | 190 734 | 217 335 |
| Malaysia | 86 338 | - | - | - | .. | 86 338 | 83 258 |
| Mexico | - | - | - | - | .. | - | 12 780 |
| New Zealand | 10 179 | - | - | - | .. | 10 179 | 27 167 |
| Philippines | 42 356 | - | - | - | .. | 42 356 | 39 864 |
| Romania | 32 | - | - | - | .. | 32 | 23 |
| South Africa | 12 410 | 9 979 | - | - | .. | 22 389 | 23 671 |
| Sri Lanka | 31 699 | - | - | - | .. | 31 699 | 18 240 |
| Swaziland | - | - | 17 445 | - | .. | 17 445 | 18 595 |
| Taiwan | 34 627 | - | - | - | .. | 34 627 | 56 746 |
| Thailand | - | - | - | - | .. | - | 3 025 |
| United Kingdom | 807 | - | - | - | .. | 807 | 688 |
| Offshore total | 1 443 154 | 196 228 | 255 672 | 130 939 | .. | 2 025 993 | 1 576 373 |
| Total sales | 1 743 748 | 2 667 132 | 1 481 627 | 664 240 | .. | 6 556 747 | 5 051 549 |

Source: Potash and Phosphate Institute.

[1] Common specifications are: standard -28 to +65 mesh, special standard -35 to +200 mesh, coarse -8 to +28 mesh, granular -6 to +20 mesh, each grading a minimum of 60 per cent $K_2O$ equivalent, soluble and chemical grade a minimum of 62 per cent $K_2O$ equivalent. [2] Standard includes Special Standard, sales of which were 125 449 t $K_2O$ equivalent in 1982, and 140 406 in 1983. [3] Chemical sales are included in standard grade sales and totalled 60 008 t in 1983.

- Nil; .. Not available.

### TABLE 3. CANADA, POTASH PRODUCTION AND TRADE, YEARS-ENDED JUNE 30, 1966, 1971, 1976-84

| | Production[2] | Imports[1,2] | Exports[2] |
|---|---|---|---|
| | (tonnes $K_2O$ equivalent) | | |
| 1966 | 1 748 910 | 31 318 | 1 520 599 |
| 1971 | 3 104 782 | 26 317 | 3 011 113 |
| 1976 | 4 833 296 | 16 445 | 4 314 150 |
| 1977 | 4 803 015 | 24 289 | 4 175 473 |
| 1978 | 6 206 542 | 26 095 | 5 828 548 |
| 1979 | 6 386 617 | 21 819 | 6 256 216 |
| 1980 | 7 062 996 | 20 620 | 6 432 124 |
| 1981 | 7 336 973 | 35 135 | 6 933 162 |
| 1982 | 6 042 623 | 25 437 | 5 400 662 |
| 1983 | 5 378 842 | 21 846 | 4 864 219 |
| 1984 | 7 155 599 | 17 934 | 6 730 733 |

Source: Potash and Phosphate Institute, Canadian Fertilizer Institute.

[1] Includes potassium chloride, potassium sulphate, except that contained in mixed fertilizers. [2] Change of data source. Prior to 1978 figures were obtained from Statistics Canada.

### TABLE 4. CANADA, POTASH PRODUCTION AND SALES BY QUARTERS, 1984 AND 1983

| | Total (1983) | 1st quarter | 2nd quarter | 3rd quarter | 4th quarter |
|---|---|---|---|---|---|
| | | | (000 tonnes) | | |
| Production | 5 928.4 | 2 087.6 | 2 048.6 | 1 552.3 | 2 060.1 |
| Sales | | | | | |
| North America | 4 530.8 | 1 020.3 | 1 012.8 | 1 383.8 | 1 104.6 |
| Offshore | 2 026.0 | 678.5 | 630.1 | 711.7 | 524.4 |
| Ending Inventory | 861.5 | 1 020.3 | 1 656.1 | 1 112.8 | 1 543.0 |

Source: Potash and Phosphate Institute.

TABLE 5. CANADA, POTASH SALES BY PRODUCT AND AREA, 1982 AND 1983

| | | Agricultural | | | | | Industrial | | | Total Sales |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Standard | Coarse | Granular | Soluble | Total | Standard | Soluble | Total | |
| | | (tonnes $K_2O$ equivalent) | | | | | | | | |
| Alberta | 1982 | 708 | 1 546 | 15 822 | 1 289 | 19 365 | 3 042 | 110 | 3 152 | 22 517 |
| | 1983 | 590 | 4 746 | 19 934 | 1 680 | 26 950 | 1 961 | 469 | 2 430 | 29 380 |
| British Columbia | 1982 | 15 | 1 544 | 3 920 | 3 310 | 8 789 | - | - | - | 8 789 |
| | 1983 | - | 217 | 5 687 | 32 | 5 936 | - | - | - | 5 936 |
| Manitoba | 1982 | 132 | 7 040 | 13 949 | 760 | 21 881 | - | - | - | 21 881 |
| | 1983 | 22 | 4 618 | 10 551 | 634 | 15 825 | - | - | - | 15 825 |
| New Brunswick | 1982 | - | 6 184 | - | - | 6 184 | - | - | - | 6 184 |
| | 1983 | - | 11 325 | 2 493 | - | 13 818 | - | - | - | 13 818 |
| Nova Scotia | 1982 | - | 6 025 | - | - | 6 025 | - | - | - | 6 025 |
| | 1983 | 276 | 4 668 | - | - | 4 944 | - | - | - | 4 944 |
| Ontario | 1982 | 366 | 86 108 | 32 723 | 354 | 119 551 | 1 710 | 4 072 | 5 782 | 125 333 |
| | 1983 | 902 | 189 111 | 6 253 | 1 407 | 197 673 | 2 953 | 2 824 | 5 777 | 203 450 |
| Prince Edward Island | 1982 | - | 10 460 | - | - | 10 460 | - | - | - | 10 460 |
| | 1983 | 401 | 4 783 | 5 192 | - | 10 376 | - | - | - | 10 376 |
| Quebec | 1982 | - | 44 982 | 13 208 | - | 58 190 | 306 | - | 306 | 58 496 |
| | 1983 | 500 | 51 941 | 31 705 | - | 84 146 | 318 | - | 318 | 84 464 |
| Saskatchewan | 1982 | 1 446 | 800 | 3 513 | 1 446 | 7 205 | 4 188 | 1 721 | 5 909 | 13 114 |
| | 1983 | 12 | 2 011 | 5 230 | 794 | 8 047 | 5 728 | 2 361 | 8 089 | 16 136 |
| Newfoundland | 1982 | - | - | - | - | - | - | - | - | - |
| | 1983 | 409 | - | - | - | 409 | 166 | - | 166 | 575 |
| Totals | 1982 | 2 667 | 164 689 | 83 135 | 7 159 | 257 650 | 9 246 | 5 903 | 15 149 | 272 799 |
| | 1983 | 3 112 | 273 420 | 87 045 | 4 547 | 368 124 | 11 126 | 5 654 | 16 780 | 384 904 |

Source: Potash and Phosphate Institute.
- Nil.

## TABLE 6. CANADA, POTASH INVENTORY, PRODUCTION, DOMESTIC SHIPMENTS AND EXPORTS, 1983

| | | | | | Exports | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Domestic Shipments | | United States | | Offshore | |
| | Beginning Inventory | Production | Agri-cultural | Non-agri-cultural | Agri-cultural | Non-agri-cultural | | Total Shipments |
| | | | | | (000 tonnes $K_2O$) | | | |
| January | 1 486.2 | 357.8 | 22.5 | 0.8 | 267.5 | 14.2 | 154.2 | 459.2 |
| February | 1 417.0 | 263.5 | 11.4 | 1.5 | 215.8 | 10.7 | 119.5 | 358.9 |
| March | 1 272.2 | 626.5 | 41.3 | 1.0 | 276.4 | 18.0 | 143.1 | 479.8 |
| April | 1 386.0 | 599.1 | 31.7 | 0.7 | 252.3 | 14.6 | 174.2 | 473.5 |
| May | 1 515.3 | 521.5 | 62.1 | 0.9 | 370.8 | 13.6 | 177.1 | 624.5 |
| June | 1 409.2 | 540.6 | 23.1 | 1.6 | 318.6 | 16.9 | 96.6 | 456.8 |
| Sub-total | | 2 909.0 | 192.1 | 6.5 | 1 701.4 | 88.0 | 864.7 | 2 852.7 |
| July | 1 494.0 | 313.0 | 3.3 | 1.1 | 239.4 | 10.9 | 125.9 | 380.6 |
| August | 1 432.9 | 351.4 | 16.8 | 2.6 | 437.4 | 12.6 | 278.8 | 748.2 |
| September | 1 060.7 | 484.6 | 48.4 | 1.8 | 475.6 | 15.0 | 189.2 | 730.0 |
| October | 879.7 | 612.9 | 21.5 | 1.5 | 422.3 | 21.5 | 191.7 | 658.5 |
| November | 765.4 | 629.1 | 39.4 | 2.1 | 424.5 | 14.3 | 171.6 | 651.9 |
| December* | 759.7 | 628.3 | 46.6 | 1.2 | 264.5 | 18.3 | 204.2 | 534.8 |
| Sub-total | | 3 019.3 | 176.0 | 10.3 | 2 263.7 | 92.6 | 1 161.4 | 3 704.0 |
| Total 1983 | | 5 928.3 | 368.1 | 16.8 | 3 965.1 | 180.6 | 2 026.1 | 6 556.7 |
| 1982 | | 5 216.4 | 267.9 | 14.9 | 3 065.8 | 175.7 | 1 576.8 | 5 101.1 |
| % change 1983/82 | | +13.6 | +37.4 | +12.8 | +29.3 | +2.8 | +28.5 | +28.5 |

Source: Potash and Phosphate Institute of North America.
* Inventory at the end of December 1983 is estimated at 861 500 tonnes.

## TABLE 7. CANADA, POTASH INVENTORY, PRODUCTION, DOMESTIC SHIPMENTS AND EXPORTS, 1984

| | | | | | Exports | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Domestic Shipments | | United States | | Offshore | |
| | Beginning Inventory | Production | Agri-cultural | Non-agri-cultural | Agri-cultural | Non-agri-cultural | | Total Shipments |
| | | | | | (000 tonnes $K_2O$) | | | |
| January | 861.5 | 669.2 | 31.9 | 2.1 | 376.4 | 13.6 | 227.4 | 651.4 |
| February | 941.1 | 678.6 | 28.1 | 1.6 | 301.7 | 11.6 | 219.4 | 562.4 |
| March | 1 026.8 | 739.8 | 30.3 | 2.1 | 214.6 | 14.6 | 231.7 | 493.3 |
| April | 1 250.3 | 707.9 | 28.5 | 1.1 | 298.8 | 17.2 | 229.6 | 575.2 |
| May | 1 440.9 | 698.6 | 58.7 | 1.8 | 389.8 | 18.0 | 168.3 | 636.6 |
| June | 1 460.7 | 642.2 | 15.9 | 2.1 | 231.5 | 18.7 | 232.5 | 500.7 |
| Sub-total | | 4 136.3 | 193.4 | 10.8 | 1 812.8 | 93.7 | 1 308.9 | 3 419.6 |
| July | 1 656.1 | 401.3 | 9.8 | 1.7 | 205.5 | 9.5 | 260.0 | 486.6 |
| August | 1 558.6 | 485.7 | 43.6 | 1.9 | 604.3 | 15.6 | 210.1 | 875.5 |
| September | 1 153.0 | 665.2 | 33.0 | 1.8 | 426.0 | 16.9 | 241.6 | 719.3 |
| October | 1 112.8 | 734.0 | 24.4 | 2.0 | 263.1 | 17.6 | 181.9 | 489.0 |
| November | 1 372.6 | 720.6 | 23.0 | 1.5 | 217.0 | 26.4 | 180.6 | 448.5 |
| December* | 1 555.4 | 605.5 | 25.0[e] | 2.0[e] | 412.7[e] | 18.0[e] | 160.4 | 618.1[e] |
| Sub-total | | 3 612.3 | 158.8[e] | 10.9[e] | 2 128.6[e] | 104.0[e] | 1 234.6[e] | 3 637.0[e] |
| Total 1984 | | 7 748.6 | 352.2[e] | 21.7[e] | 3 941.4[e] | 197.7[e] | 2 543.5[e] | 7 056.6[e] |
| 1983 | | 5 928.3 | 368.1 | 16.8 | 3 965.1 | 180.6 | 2 026.1 | 6 556.7 |
| % change 1984/83 | | +30.7 | -3.8 | +29.2 | -0.6 | +9.5 | +25.5 | +7.6 |

Source: Potash and Phosphate Institute of North America.
* Inventory at the end of December 1984 is estimated at 1 543 000 tonnes.
[e] Estimated by Mineral Policy Sector, Energy, Mines and Resources Canada.

**TABLE 8. WORLD POTASH PRODUCTION**

| | 1980 | 1981 | 1982 | 1983P | 1984e |
|---|---|---|---|---|---|
| | (000 tonnes $K_2O$) | | | | |
| Canada | 7 303 | 7 147 | 5 352 | 5 930 | 7 700 |
| Chile | 25 | 21 | 22 | 22 | 22 |
| China | 12 | 20 | 26 | 25 | 25 |
| France | 1 894 | 1 828 | 1 706 | 1 539 | 1 700 |
| Germany Dem. Rep. | 3 405 | 3 497 | 3 200 | 3 341 | 3 400 |
| Germany, Fed. Rep. | 2 737 | 2 591 | 2 057 | 2 419 | 2 650 |
| Israel | 797 | 832 | 946 | 942 | 1 000 |
| Italy | 102 | 125 | 115 | 133 | 140 |
| Jordan | - | - | 9 | 168 | 280 |
| Spain | 658 | 728 | 694 | 659 | 700 |
| U.S.S.R. | 8 064 | 8 449 | 8 079 | 8 400e | 9 000 |
| United Kingdom | 306 | 284 | 240 | 303 | 330 |
| United States | 2 239 | 2 156 | 1 784 | 1 429 | 1 600 |
| | 27 542 | 27 678 | 24 515 | 25 310 | 28 547 |

Sources: International Fertilizer Industry Association Ltd.; U.S. Bureau of Mines and Energy, Mines and Resources Canada.
P - Preliminary; e - Estimated; - Nil.

## TABLE 9. CANADA, POTASH MINES - CAPACITY PROJECTIONS

| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (000 tonnes $K_2O$ equivalent) | | | | | | | | | | |
| PCS | | | | | | | | | | | |
| - Allen (60%) | 570 | 570 | 570 | 570 | 570 | 570 | 570 | 570 | 570 | 570 | 570 |
| - Cory | 830 | 830 | 830 | 830 | 830 | 830 | 830 | 830 | 830 | 830 | 830 |
| - Esterhazy (25% of IMC) | 580 | 580 | 580 | 580 | 580 | 580 | 580 | 580 | 580 | 580 | 580 |
| - Lanigan | 545 | 690 | 690 | 690 | 690 | 690 | 1 240 | 1 740 | 1 740 | 1 740 | 1 740 |
| - Rocanville | 725 | 750 | 830 | 1 160 | 1 160 | 1 160 | 1 160 | 1 160 | 1 160 | 1 160 | 1 160 |
| Sub-total | 3 250 | 3 420 | 3 500 | 3 830 | 3 830 | 3 830 | 4 380 | 4 880 | 4 880 | 4 880 | 4 880 |
| CCP | 815 | 815 | 815 | 815 | 815 | 815 | 815 | 815 | 815 | 815 | 815 |
| Cominco | 545 | 545 | 600 | 655 | 655 | 655 | 655 | 655 | 655 | 655 | 655 |
| IMC | 1 750 | 1 750 | 1 750 | 1 750 | 1 750 | 1 750 | 1 750 | 1 750 | 1 750 | 1 750 | 1 750 |
| PPG (Kalium) | 845 | 845 | 1 055 | 1 055 | 1 055 | 1 055 | 1 055 | 1 320 | 1 320 | 1 320 | 1 320 |
| PCA | 420 | 420 | 420 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 |
| Kidd Creek (Allen 40%) | 380 | 380 | 380 | 380 | 380 | 380 | 380 | 380 | 380 | 380 | 380 |
| Sub-total | 4 755 | 4 755 | 5 020 | 5 285 | 5 285 | 5 285 | 5 285 | 5 550 | 5 550 | 5 550 | 5 550 |
| Total Saskatchewan | 8 005 | 8 175 | 8 520 | 9 115 | 9 115 | 9 115 | 9 665 | 10 430 | 10 430 | 10 430 | 10 430 |
| Denison, N.B. | - | - | - | - | - | 200 | 450 | 650 | 780 | 780 | 780 |
| PCA, N.B. | - | - | - | 50 | 200 | 300 | 380 | 380 | 380 | 545 | 545 |
| Total New Brunswick | - | - | - | 50 | 200 | 500 | 830 | 1 030 | 1 160 | 1 325 | 1 325 |
| Canada (firm) | 8 005 | 8 175 | 8 520 | 9 165 | 9 315 | 9 615 | 10 495 | 11 460 | 11 590 | 11 755 | 11 755 |
| (unspecified) | - | - | - | - | - | - | - | - | - | 100 | 400 |
| TOTAL | 8 005 | 8 175 | 8 520 | 9 165 | 9 325 | 9 615 | 10 495 | 11 460 | 11 590 | 11 855 | 12 155 |

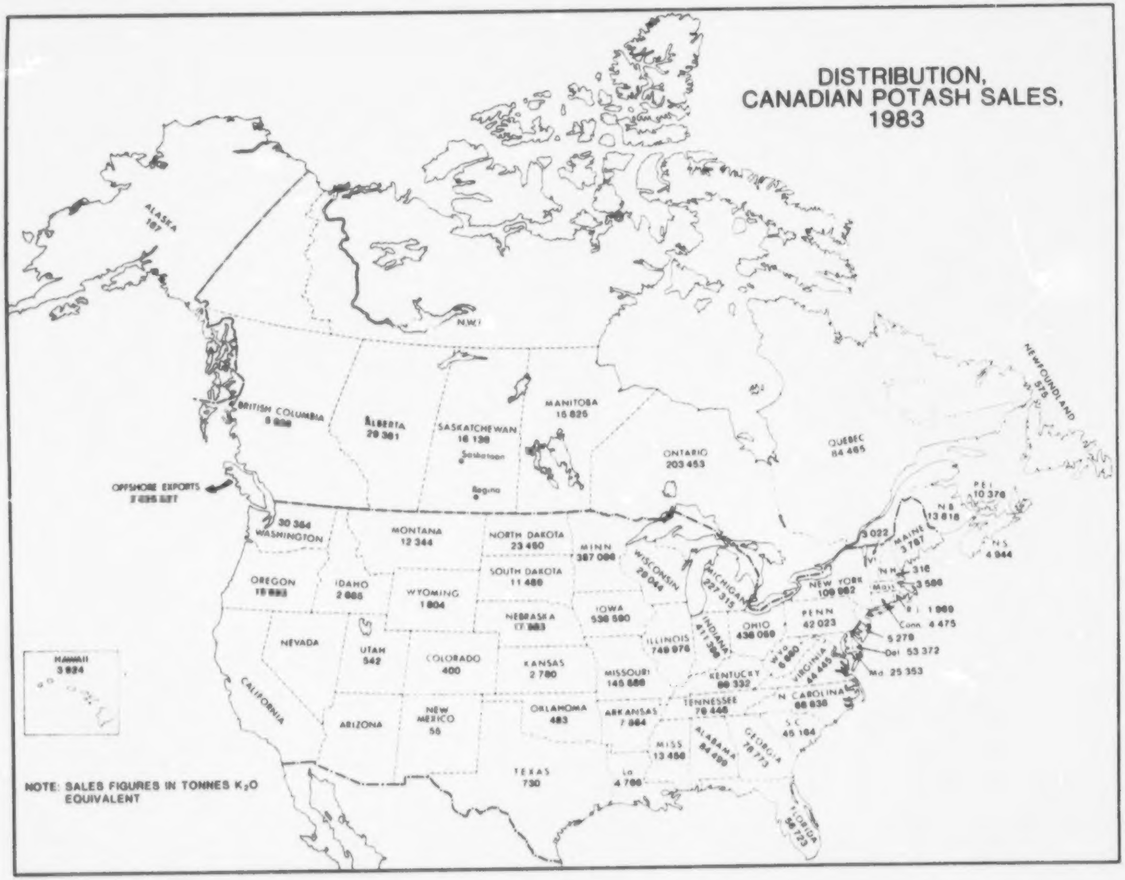
Note: Capacity means "rated" capacity; under normal conditions Canadian mines operate at about 90 per cent of rated capacity.
- Nil.

TABLE 10. WORLD POTASH CAPACITY 1982-92

| | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (000 tonnes $K_2O$ equivalent) | | | | | | | | | | |
| North America | | | | | | | | | | | |
| Canada | 8 520 | 9 165 | 9 315 | 9 615 | 10 495 | 11 460 | 11 590 | 11 855 | 12 155 | 12 700 | 13 200 |
| United States | 2 090 | 1 880 | 1 770 | 1 770 | 1 770 | 1 610 | 1 560 | 1 450 | 1 450 | 1 450 | 1 450 |
| Total | 10 610 | 11 045 | 11 085 | 11 385 | 12 265 | 13 070 | 13 150 | 13 305 | 13 605 | 14 070 | 14 570 |
| Western Europe | | | | | | | | | | | |
| France | 2 000 | 2 000 | 2 000 | 1 800 | 1 700 | 1 700 | 1 700 | 1 700 | 1 700 | 1 600 | 1 500 |
| Germany, Fed. Rep. | 2 900 | 2 700 | 2 700 | 2 800 | 2 800 | 2 800 | 2 800 | 2 800 | 2 800 | 2 800 | 2 800 |
| Italy | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| Spain | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 |
| United Kingdom | 360 | 360 | 360 | 360 | 360 | 360 | 360 | 360 | 360 | 360 | 360 |
| Total | 6 260 | 6 060 | 6 060 | 5 960 | 5 860 | 5 860 | 5 860 | 5 860 | 5 860 | 5 760 | 5 660 |
| Eastern Europe | | | | | | | | | | | |
| Germany, Dem. Rep. | 3 600 | 3 600 | 3 600 | 3 600 | 3 600 | 3 600 | 3 600 | 3 600 | 3 600 | 3 600 | 3 600 |
| U.S.S.R. | 10 900 | 11 200 | 11 500 | 11 700 | 11 900 | 12 200 | 12 700 | 13 100 | 13 400 | 13 800 | 14 000 |
| Total | 14 500 | 14 800 | 15 100 | 15 300 | 15 500 | 15 800 | 16 300 | 16 700 | 17 000 | 17 400 | 17 600 |
| Asia | | | | | | | | | | | |
| Israel | 1 000 | 1 000 | 1 000 | 1 260 | 1 260 | 1 260 | 1 260 | 1 260 | 1 260 | 1 260 | 1 260 |
| Jordan | - | 200 | 300 | 450 | 600 | 720 | 720 | 720 | 720 | 720 | 720 |
| China, People's Rep. | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Total | 1 030 | 1 230 | 1 330 | 1 740 | 1 890 | 2 010 | 2 010 | 2 010 | 2 010 | 2 010 | 2 010 |
| Latin America | | | | | | | | | | | |
| Brazil | - | - | - | - | 100 | 150 | 200 | 250 | 300 | 300 | 300 |
| Chile | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Mexico | - | - | - | - | 10 | 30 | 30 | 50 | 50 | 50 | 50 |
| Total | 30 | 30 | 30 | 30 | 140 | 210 | 260 | 330 | 380 | 380 | 380 |
| Other | - | - | - | - | 50 | 50 | 100 | 100 | 100 | 100 | 150 |
| World Total | 32 430 | 33 165 | 33 605 | 34 415 | 35 705 | 37 000 | 37 680 | 38 305 | 38 955 | 39 720 | 40 370 |

Note: Under "other" is the probable small production from brines in Australia, Peru or Tunisia.
- Nil.

# DISTRIBUTION, CANADIAN POTASH SALES, 1983


ALASKA 187
N.W.T.
BRITISH COLUMBIA 5 606
ALBERTA 29 361
SASKATCHEWAN 16 138
Saskatoon
Regina
MANITOBA 15 825
ONTARIO 203 453
QUEBEC 84 465
NEWFOUNDLAND 575
P.E.I. 10 376
N.B. 13 818
N.S. 4 944
OFFSHORE EXPORTS 7 035 327
30 364 WASHINGTON
OREGON 15 883
IDAHO 2 885
MONTANA 12 344
WYOMING 1 804
NEVADA
CALIFORNIA
UTAH 542
COLORADO 400
ARIZONA
NEW MEXICO 55
NORTH DAKOTA 23 450
SOUTH DAKOTA 11 480
NEBRASKA 17 983
KANSAS 2 780
OKLAHOMA 483
TEXAS 730
MINN 387 066
IOWA 536 580
MISSOURI 145 886
ARKANSAS 7 864
La 4 706
WISCONSIN 29 044
ILLINOIS 749 976
MICHIGAN 227 315
INDIANA 411 388
OHIO 436 060
KENTUCKY 88 332
TENNESSEE 79 446
MISS 13 456
ALABAMA 84 490
GEORGIA 78 773
FLORIDA 58 723
S.C. 45 164
N. CAROLINA 88 838
VIRGINIA 44 445
W.Va. 6 680
PENN 42 023
NEW YORK 109 862
Vt 3 022
MAINE 3 787
N.H. 316
Mass 3 586
R.I. 1 969
Conn. 4 475
5 279
Del 53 372
Md 25 353
HAWAII 3 824

NOTE: SALES FIGURES IN TONNES $K_2O$ EQUIVALENT

# Rare Earths

D.E.C. KING

Rare earth metals or lanthanides encompass fifteen chemically similar metals, but two other metals, scandium and yttrium, closely resemble this group and are usually classed with the lanthanides. The minerals containing these metals are actually not rare, but relatively rare metals such as beryllium, zirconium, columbium, tantalum, thorium and uranium are often found associated with them in nature. The metals were originally classified "rare" because they are seldom concentrated in nature like most other elements and their widespread occurrence in the earth's crust was recognized only in recent times. The term "earth" is a retention of early terminology for insoluble natural oxides.

Lanthanide-bearing minerals contain all members of the rare earth group of elements, but some are classified as the "light" group and the remainder the "heavy" group. Cerium is generally the most abundant element in minerals containing the "light" rare earths, which are also associated with scandium. The "heavy" rare earths are usually found in minerals which often contain substantial proportions of yttrium. The rare earth metals are typically associated with alkaline igneous rocks and also occur as secondary concentrations in placer, beach sand and phosphatic sedimentary deposits. Commercial production has been derived from carbonatite occurrences, placer and beach sand deposits, uranium ores, and phosphatic rocks.

Monazite is a rare earth phosphate that contains nearly 70 per cent rare earth oxides (REO) and about 1.5 per cent yttrium oxide. Placer deposits of heavy mineral sands are the major source of monazite which is usually recovered as a byproduct of rutile, ilmenite and zircon mining operations. Only in a few cases have deposits been exploited primarily for monazite; such a deposit in South Africa was the world's major source of monazite from 1953 to 1963. Bastnaesite is a fluorcarbonate of the cerium subgroup which contains about 75 per cent REO and 0.05 per cent yttrium. It has been found in economic quantities in vein deposits, contact metamorphic zones, pegmatites and other igneous rocks. Xenotime, the yttrium phosphate isomorph of monazite is the main source of yttrium and the "heavy" rare earth elements.

World reserves of rare earth metals have been estimated at about 50 million t of contained rare earth oxides (excluding China which has large reserves of bastnaesite) while annual world consumption is only of the order of 20 000 to 25 000 t of contained REO. The total world demand for yttrium oxide is of the order of about 350 tpy. Total samarium oxide demand is of the order of 350-400 tpy.

The rare earth elements are used as metals, oxides, halides and other compounds. Because of the difficulty of separating the individual rare earth elements, most industrial applications still employ mixtures of the elements. Originally these mixtures were in the proportions occurring in the ore sources but there is a growing demand for individual rare earth elements or mixtures enriched by one specific element. However, the commercial demand for individual elements hardly ever matches the proportions occurring in ore sources so some elements are invariably in oversupply. This tends to spur research into uses for the less popular and more abundant elements. Cerium, neodymium, yttrium and lanthanum are considerably more abundant than thulium, lutetium, terbium, holmium and europium (by anywhere from 20 to over 200 times) and the remaining rare earth elements are of intermediate abundance.

New markets for specific members of the rare earth group, have resulted in increased production of all of the rare earth metals from which they must be separated because of their natural association in ores. Simultaneously, production costs for some rare earth members, produced as byproducts of the refining process, have diminished.

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Availability and declining costs have been important factors in the development of new uses. There is growing optimism that the rare earth metals industry will expand at a steady rate now that industrial uses are becoming more diverse.

## CANADIAN INDUSTRY

While substantial resources of rare earths have been identified in Canada, raw material production in the past has been limited to relatively small outputs of byproduct residues from uranium mining and hydrometallurgical operations at Elliot Lake, Ontario. These concentrates were produced from 1966 through 1970 and from 1974 through 1977. Elliot Lake uranium ores are rich in yttrium and the "heavy" rare earth elements and, in fact, were the world's major source of yttrium concentrate during the first of these two periods. The Elliot Lake ores contain about 0.11 per cent uranium oxide ($U_3O_8$), 0.028 per cent thorium oxide and 0.057 per cent rare earth oxides.

Denison Mines Limited has been the largest Canadian producer of rare earth concentrates. Denison ceased production of yttrium concentrate in 1978 because its recovery had become uneconomic owing to increased costs of chemical reagents. Marketing of the yttrium concentrate had been carried out through Molycorp, Inc. and Michigan Chemical Corporation. However, shipments to the latter company had been terminated in mid-1970 when Michigan Chemical experienced difficulty in marketing the product. Denison is reviewing the possibility of resuming production.

Rio Algom Mines Limited recovered thorium and rare earth concentrate at its Nordic mill, but discontinued this activity upon transfer of uranium milling to the Quirke mill where no thorium and rare earth facilities were installed.

In addition to the large resource in Elliot Lake uranium ores, rare earths are also associated with uranium deposits at Agnew Lake, 65 kilometres (km) east of Elliot Lake (where the REO content is about twice that of Elliot Lake ores), and in the Bancroft area of Ontario.

The Highwood Resources Ltd. property at Thor Lake, located about 65 miles southeast of Yellowknife, contains several zones, each composed of somewhat different mineralization. The Lake zone is enriched in tantalum, columbium, rare earths and zirconium, the R zone contains rare earths and beryllium, the S zone is enriched in uranium, thorium and columbium and the T zone contains columbium, uranium and beryllium. Geological research on the Thor Lake area is currently being conducted at the University of Alberta with federal government support.

Drilling on the R and T zones has identified a beryllium enrichment of about 1.8 million t grading 0.75 per cent beryllium oxide (BeO). With existing resources and the expectation of further discoveries, Highwood is currently undertaking a pre-feasibility study, including metallurgical testing, to assess the economics and viability of an open pit beryllium mine and concentrator.

The Strange Lake deposit, owned by Iron Ore Company of Canada (IOC), is located near Lac Brisson on the Quebec-Labrador boundary and approximately 155 miles northeast of Schefferville. It is reported to contain large tonnages of yttrium and zirconium as well as large quantities of columbium, beryllium and rare earth elements. The deposit, discovered by IOC in 1979 in a follow-up to government surveys, is located at shallow depth and is amenable to open pit mining. The deposit is being evaluated by IOC with the objective of defining economic reserves.

Significant quantities of rare earths are found in a number of Canadian pyrochlore-bearing carbonatite deposits such as the Niobec Inc. mine near St. Honoré, Quebec and in deposits on the Manitou Islands, Lake Nipissing, Ontario.

Phosphorite formations in western Canada contain small quantities of rare earths, as do Florida phosphates imported into Canada for the production of phosphoric acid. Other potential sources include apatite-rich carbonatites in Ontario and Quebec. Rare earth elements, primarily the light element group, are associated with apatite in the Nemegos No. 6 magnetite deposit, which is located in the Chapleau area of Ontario.

Sherritt Gordon Mines Limited has been producing samarium-cobalt alloy powder at Fort Saskatchewan, Alberta since 1980 as a means of marketing cobalt with added value. Through continued research and development, Sherritt has improved the processing technology originally purchased from Canadian General Electric Ltd. in 1979, to the point that in 1984 their $SmCo_5$ (1-5) type alloy powder was of fully competitive quality. Production of type 1-5 alloy powder is in tonnage quantities, dependent to a certain extent on samarium supply, and all of this material is exported to a number of countries. Sherritt has also carried out research and development on the production of another class of samarium-cobalt alloy powder designated 2-17, with the aim of bringing it to full scale production. This alloy, which nominally contains 24 per cent samarium, compared with 34.5 per cent in the 1-5 type, has a lower resistance to demagnetization but a higher energy per unit volume (energy product) than the type 1-5. Research on the production of magnets from 2-17 powder has already been successful to the point that this technology has been licensed to a major U.S. magnet producer.

## WORLD INDUSTRY

Total world production of rare earth minerals in 1983 was estimated to have been about 41 300 t, of which bastnaesite from the United States accounted for 17 300 t, and monazite 24 000 t. The latter was provided mainly by Australia (15 700 t), India (4 200 t), Brazil (2 000 t) and the United States (1 000 t). The United States and Australia together produced about 80 per cent of total world mineral production, excluding China which has the capacity to produce 9 000 tpy. India's production of monazite increased by 27 per cent from 1980 to 1982.

Estimates of rare earth minerals reserves by the U.S. Bureau of Mines (USBM) indicate about 5 million t of rare earth oxide content in North America, and a world total of about 7 million t. These totals exclude the reported huge reserves of China which amount to 36 million t of rare earth oxides in bastnaesite.

Total world reserves of yttrium, excluding China, were estimated by USBM to amount to 34 000 t of which 18 000 t are in India and 5 000 t in Australia. The potential in Canada is large but so far undefined.

Although the consumptions of rare earths and yttrium are increasing strongly, world reserves are clearly more than sufficient to meet foreseeable demand.

The rare earth elements are principally extracted from two minerals, monazite and bastnaesite. Nearly all of the world's bastnaesite production is from a mine at Mountain Pass, California, which is owned and operated by Molycorp Inc. Very large reserves of bastnaesite also exist in China which also has the processing capability to produce separate and pure rare earth elements. China's proven reserves of bastnaesite amount to 36 million t and occur in a massive iron ore deposit in Inner Mongolia.

Monazite is usually recovered commercially from heavy mineral beach sands with rutile, ilmenite and zircon. It is found in a number of countries but the main producing countries are Australia, the United States, India, Brazil, and Malaysia. Australia produces over one half of the total world output and is the only major mineral-producing country possessing no processing capacity. Both India and Brazil prohibit the export of monazite because of its thorium content, so monazite is processed in these countries to remove thorium and to produce mixed rare earth compounds.

The United States, Japan and France are the leading processors of rare earth minerals, and the two companies Molycorp Inc. in the United States and Rhone-Poulenc Inc. of France dominate this industry. Generally speaking, most of the output from the United States and Japan is from bastnaesite while about one half of the world's output of monazite is processed in western Europe. The United States is also an important processor of monazite. Consumption of rare earth compounds, alloys and individual metals occurs mainly in the United States, Japan and western Europe.

Allied Eneabba Ltd., which accounts for more than half of the total Australian monazite output, has not increased its production capacity since the major expansion of its Geraldton plant in 1980. However, in 1981 Allied acquired property which extended its mine life to 28 years. Because monazite is a coproduct in the mining of heavy mineral sands, any slackness in demand for the associated heavy minerals such as occurred in 1982, can depress monazite output.

India Rare Earths Ltd., (IRE) which processes its own monazite to produce rare earth chlorides, fluorides, and oxides, started a new plant at Orissa in 1984. It also announced plans to diversify into the production of yttrium, gadolinium and samarium concentrates.

China has become a significant producer of rare earth compounds and alloys, with the potential to create a significant impact on the rare earth market.

The China Rare Earth Co. has been collaborating with Japax In[illegible] of Japan since 1981 to develop new rare earth smelting technology and has been supplying Japax with 2 000 tpy of rare earth concentrates. Mitsui Mining & Smelting Co. Ltd. of Japan was helping the Baotou Iron & Steel Co. to produce rare earth concentrates in Inner Mongolia. Japan is China's leading market for rare earths, importing about 1 000 tpy.

Following the takeover of Molycorp by Union Oil Company of California in 1977, Molycorp REO production statistics have not been made available; only tonnages of rare earth concentrates have since been reported.

In 1981, Molycorp completed a $15 million expansion of its solvent extraction capacity at Mountain Pass. The new circuit has increased by 35 per cent, its capacity to produce samarium and gadolinium oxides, as well as high purity oxides of lanthanum, cerium, praeseodymium, and neodymium. Molycorp also produces high purity oxides and compounds at Washington, Pennsylvania, where a facility was completed in 1980 to produce samarium cobalt alloys. The company has other production facilities for high purity compounds at York, Pennsylvania and at Louviers, Colorado where high purity yttrium oxide is made from xenotime.

Davison Specialty Chemicals Division of W.R. Grace & Co., which processes monazite almost solely for its own catalyst production, started operating a new 23 000 tpy facility at Curtis Bay, Maryland in 1981 to produce zeolite-rare earth catalysts. Catalyst production was also increased at Davison's plants at Lake Charles and South Gate, California.

Ronson Metals Corporation increased its production of mischmetal by 25 per cent in 1980 and a further 20 per cent in 1983. Through its subsidiary Cerium Metals Corporation, which produces alloys of cerium, lanthanum and didymium (a commercial mixture of rare earth metals enriched in neodymium and praeseodymium), cerium free mischmetal, and high-purity samarium metal, Ronson began in 1984 to produce neodymium metal for magnet manufacture.

Reactive Metals and Alloys Corporation installed new arc furnaces at its West Pittsburgh plant during the early 1980s to produce specialty silicon alloys and to triple its capacity for producing rare earth silicide.

Rhône Poulenc Inc. has its main operation at La Rochelle, France where it has an annual production capacity of about 4 600 t of light rare earth elements and 370 t of heavies. Separations of the elements are carried out by solvent extraction in both chloride and nitrate aqueous media employing over 1,000 mixer-settlers. The company completed a 4 000 tpy rare earth separation and finishing plant at Freeport, Texas in 1981; production is from concentrates imported from the parent company.

Th Goldschmidt AG of West Germany which produces by the "Co-reduction Process" a range of alloys based on rare earth elements, ceased production of mischmetal in early-1984. It continued to produce alloys of rare earth elements with cobalt, iron and other transition elements, and in its latest developments, emphasized the production of neodymium, its compounds and alloys.

Treibacher Chemische Werke AG of West Germany is the leading world producer of mischmetal in its various forms, and will probably capture a large part of the mischmetal business relinquished by Th Goldschmidt AG.

Plant closures by British Flint and Cerium Manufacturers Ltd. in 1981, associated with Ronson Metals Corp., and by Steetley Chemicals Ltd. in 1982 after its new plant had operated for only a year, were said to be recession related. Rare Earth Products Ltd., a division of Johnson Matthey Chemicals Ltd. is a relatively small producer of the full range of individual pure rare earth metals and compounds. Its Widnes plant was working to full capacity in 1984, taking advantage of the upturn in the rare earth metals industry. The company was expanding its capacity for rare earth compounds. London and Scandinavian Metallurgical Co. Ltd., a subsidiary of Metallurg Inc., produces cerium oxide polishing powders using bastnaesite as a starting raw material.

There are about a dozen companies in Japan which produce a comprehensive range of rare earth metals, alloys and compounds for all categories of consumption. Japanese companies were active in joint ventures in China, Malaysia and the United States, and in the development of improved extraction and separation technology. The Asahi Chemical Industry Co. Ltd. is developing separation technology based on ion exchange chromatography with the aim of greatly reducing the number of processing steps and equipment units.

## CONSUMPTION AND USES

Rare earths have several unique properties which enable them to be employed in distinctly different ways. Because of the similarity of their chemical and some of their physical properties, mixtures of rare earths as alloys or compounds can be applied to certain applications. However, other uses, which depend on individual chemical and nuclear properties, require specific rare earth elements containing no more than about 10 per cent of the other rare earths. Consequently, there is a trend towards the greater use of specific rare earths and of mixtures enriched in individual rare earth components.

Rare earth mixtures are used in catalysts, master alloys, other alloys and glass polishing compounds. Individual rare earth metals or compounds are used in magnetic materials, phosphors, neutron capture applications, glass and ceramics.

Mischmetal, (an alloy containing a mixture of light rare earths generally in the ratio found in the ore), ferrocerium, and cerium silicide are added to some grades of high-strength low-alloy (HSLA) and stainless steels to effect sulphide shape control. This practice has been somewhat in decline in recent years because of a trend towards greater removal of sulphur during steelmaking. However, the need for weldability in these steels appears to be arresting and even reversing the trend towards ever-lower sulphur levels, and the decline in the use of rare metals in steels, accordingly appears to be levelling off.

The development of magnesium alloys with improved hot strength is an example of a trend towards the greater use of specific rare earth metals. Magnesium Elektron Ltd. of the United Kingdom has progressively improved the properties of its range of magnesium alloys, firstly by enriching rare earth additions with yttrium, and later with neodymium and other elements. The rare earth additions combine to form precipitates which strengthen or lock the alloy crystals in place under load.

Another major application for rare earths is as additions to catalysts which are used in the cracking operation of petroleum refining. Rare earths modify the surface activity of other compounds, and are added as natural or cerium-depleted mixtures of rare earth chlorides to zeolite catalysts. They have only recently been available in tonnages large enough to satisfy this large and growing market. Automobile exhaust systems could be another substantial area for the use of natural rare earth mixtures (cerium-rich) because of their ability to stabilize the alumina matrix which carries the active catalysts. Rare earths are also used in many other catalytic applications.

Glass polishing and decolourizing are two distinctly separate applications for rare earths. Natural mixtures of rare earth oxides, high in cerium, are very effective as polishing powders in high-quality optical and plate glass, and mirror applications. The use of plastic lens systems in popular lightweight cameras has reduced demand to some extent, but the increasing demand for video tubes with glass screens could offset this.

Cerium oxide, in small quantities, is an effective glass decolourizer. Owing to its ability to absorb ultraviolet light, cerium oxide is used in the manufacture of transparent bottles to inhibit food spoilage. Neodymium, praeseodymium, erbium and holmium are effective in welders' goggles, sunglasses and optical filters because of their absorption characteristics. Lanthanum oxide is used in optical lenses to increase the refractive index of the glass. A recent development involves light polarization and electro-optic switching in pilots' protective goggles for automatically blocking the brightness of a nuclear flash. The switching device is based on ceramic lead-lanthanum zirconate-titanate. For glass colouring, praseodymium imparts a yellow-green colour, neodymium a lilac, europium an orange-red, and erbium a pink colour. Lanthanum is a major component of optical glass, and cerium glass is used for windows in atomic reactors.

Many other important uses for rare earths exist, which so far use only small quantities of the elements. These include laser, nuclear, bubble memory, hydrogen storage, microwave, medicine, jewellery, solar energy, temperature measurement and various other applications. Among the individual rare earths whose sharp line emissions are effective in laser applications, neodymium in an yttrium-bearing host material, is the most commonly used.

Nuclear uses include a role as neutron absorbers in fast breeder reactors. The high captive cross sections for thermal neutrons of europium and its isotopes are utilized when used in reactor control rods. In another nuclear application, gadolinium oxide which has the highest neutron absorption of any element, is used in uranium fuels to reduce uranium consumption and improve the energy output.

Magnetic bubble memory films for data storage and processing, promises to be an important new application, particularly for gadolinium in the form of a gadolinium-gallium garnet. So far the full potential of high efficiency bubble memory systems has not been attained, perhaps because of the comparatively lower cost and greater flexibility of floppy disc systems.

Hydrogen storage is based on the ability of alloys such as lanthanum-nickel to absorb hydrogen at appropriate temperatures and pressures. Lanthanum-nickel can absorb up to 400 times its own volume of hydrogen. However, the need for large scale hydrogen storage has not yet arrived.

Garnets containing yttrium or gadolinium are used in various electronic components to control microwaves in radar, ovens and telecommunications.

There is a potentially large growth application for yttrium oxide in partially stabilized ceramic zirconia. The stabilization, which can also be achieved using magnesia or calcium oxide, toughens the zirconia for wear, heat and corrosion resistance uses. Current applications include extrusion dies, valves and pump parts, and there is active interest in its future use in the wearing surfaces in diesel engines, which would significantly enlarge the market for partially stabilized ceramic zirconia.

Individual rare earth oxides and fluorides are used in significant quantities in carbon-arc lamps where a high intensity white light is desirable. A new type of fluorescent lamp is now on the market that emphasizes three narrow spectral bands around the blue-violet, green and orange-red wavelengths to produce a synthesized white light of great brightness. The new light uses three rare earth phosphors of europium, yttrium, cerium and terbium in combinations with magnesium aluminate.

High-value applications exist in the electronics field where individual rare earth oxides are used as phosphors in colour television tubes, in temperature-compensating capacitors and in associated circuit components. Although the volume of europium and yttrium oxides used in colour television phosphors is comparatively small, the value is disproportionately large because of the high degree of purity required in this application. Europium is used as an activator in an yttrium host material to provide the primary red colour. Other activators are cerium, europium and terbium while other host materials are lanthanum and gadolinium. Phosphors utilizing terbium or thulium as activators in lanthanum and gadolinium hosts are now being used in X-ray intensifying screens to produce sharper images with indirect visible light.

The development of rare earth-cobalt magnets set the trend in broadening the demand for individual rare earths. Samarium-cobalt permanent magnets have four times the power of Alnico magnets and the consequent application of lighter weight magnetic components has played an important role in miniaturization. The volatility of the cobalt market has tended to upset this use, but in the latest development, neodymium-boron-iron magnets promise to supplant many applications for samarium-cobalt. The neodymium-boron-iron alloys have nearly double the magnetic energy of samarium-cobalt alloys, and have advantages in price since neodymium is more abundant and cheaper than samarium, and iron is cheaper and its market more stable than cobalt. However, neodymium-boron-iron alloys tend to lose their magnetism more readily than samarium-cobalt at elevated temperatures, and they are also prone to rusting. Therefore, there will continue to be many special applications for samarium-cobalt magnets which the new alloys cannot fill. Rare earth based magnets are usually fabricated by powder metallurgical methods that facilitate the procedure for inducing a high magnetic flux. Plastic epoxy-bonded samarium-cobalt magnets have also been successfully developed in Japan. High-strength permanent magnets are used in electric motors, generators, meters, speakers, and frictionless bearings.

Since the development of samarium-cobalt magnets, samarium now accounts for nearly two thirds of total consumption of high purity individual rare earth metals. The further growth in demand for rare earth based magnets seems assured. The production of neodymium-cobalt-iron magnets is already under way at Sumitomo in Japan and Crucible Magnetics Div. of Colt Industries in the United States, and production by Magnetic Materials Group in the United Kingdom is expected to begin in mid-1985. General Motors Corp. in the United States is expected to begin in mid-1985. General Motors Corp. in the United States is also developing neodymium-boron-iron magnets for motors to operate windshield wipers, electric windows and car seats, and for generators and larger induction motors.

**PRICES**

The December 1984 issue of "Industrial Minerals" quotes the following prices for concentrates of rare earth minerals:

| | |
|---|---|
| Bastnaesite concentrate 70% leached, per lb REO | $US 1.05 |
| Monazite, minimum 55% REO, tonne, fob Australia | $A 510.00-550.00 |
| Yttrium concentrate 60% $Y_2O_3$ fob Malaysia per kg | $US 46.00 |

REO Rare earth oxides; fob Free on board.

Prices for rare earth oxide and metal ingots, as quoted in the December 21, 1984 issue of "American Metal Market", were:

Rare earth oxides, U.S. dollars per lb, one-lb lots

| | Per cent | $US |
|---|---|---|
| Cerium | 99.9 | 8.00 |
| Europium | 99.99 | 650.00 |
| Gadolinium | 99.9 | 55.00 |
| Lanthanum | 99.99 | 7.00 |
| Neodymium | 99.9 | 33.00 |
| Praseodymium | 95 | 16.80 |
| Samarium | 96 | 25.00 |
| Yttrium | 99.99 | 42.00 |

At the end of 1984, prices of rare earth metal ingots in U.S. dollars per lb for minimum lots of 100 lb fob shipping point were:

| | Per cent | $US |
|---|---|---|
| Cerium | 99 | 21.00-45.46 |
| Lanthanum | 99 | 29.48-45.00 |
| Samarium | | 86.37 |
| Mischmetal | 98 | 5.60 |
| Praeseodymium | | 109.10 |

## TABLE 1. RARE EARTH ELEMENTS

| Atomic No. | Name | Symbol | Abundance in Igneous Rocks | Oxide | Per Cent Rare Earth Oxide in Total Rare Earth Oxide of Minerals | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Bastnaesite California | Monazite S. Carolina | Monazite Australia | Xenotime Malaysia | Uranium Residues Elliot Lake, Ont. |
| | (Light rare earths) | | (parts per million) | | | | | | |
| 21 | Scandium | Sc | 5.0 | $Sc_2O_3$ | - | - | - | - | - |
| 57 | Lanthanum | La | 18.3 | $La_2O_3$ | 32.0 | 19.5 | 23.0 | 0.5 | 0.8 |
| 58 | Cerium | Ce | 46.0 | $CeO_2$ | 49.0 | 44.0 | 45.5 | 5.0 | 3.7 |
| 59 | Praseodymium | Pr | 5.5 | $Pr_6O_{11}$ | 4.4 | 5.8 | 5.0 | 0.7 | 1.0 |
| 60 | Neodymium | Nd | 23.8 | $Nd_2O_3$ | 13.5 | 19.2 | 18.0 | 2.2 | 4.1 |
| 61 | Promethium | Pm | (Not measurable) | $Pm_2O_3$ | - | - | - | - | - |
| 62 | Samarium | Sm | 6.5 | $Sm_2O_3$ | 0.5 | 4.0 | 3.5 | 1.9 | 4.5 |
| 63 | Europium | Eu | 1.1 | $Eu_2O_3$ | 0.1 | 0.2 | 0.1 | 0.2 | 0.2 |
| 64 | Gadolinium | Gd | 6.3 | $Gd_2O_3$ | 0.3 | 2.0 | 1.8 | 4.0 | 8.5 |
| | (Heavy rare earths) | | | | | | | | |
| 39 | Yttrium | Y | 28.0 | $Y_2O_3$ | 0.1 | 3.0 | 2.1 | 60.8 | 51.4 |
| 65 | Terbium | Tb | 0.9 | $Tb_4O_7$ | | 0.2 | | 1.0 | 1.2 |
| 66 | Dysprosium | Dy | 4.5 | $Dy_2O_3$ | | 1.3 | | 8.7 | 11.2 |
| 67 | Holmium | Ho | 1.1 | $Ho_2O_3$ | | 0.1 | | 2.1 | 2.6 |
| 68 | Erbium | Er | 2.5 | $Er_2O_3$ | 0.1 | 0.5 | 1.0 | 5.4 | 5.5 |
| 69 | Thulium | Tm | 0.2 | $Tm_2O_3$ | | - | | 0.9 | 0.9 |
| 70 | Ytterbium | Yb | 2.6 | $Yb_2O_3$ | | 0.2 | | 6.2 | 4.0 |
| 71 | Lutetium | Lu | 0.7 | $Lu_2O_3$ | | - | | 0.4 | 0.4 |
| | Total | | 153.0 | | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

- Nil.

### TABLE 2. CANADIAN SHIPMENTS OF RARE EARTH CONCENTRATES

| | $Y_2O_3$ Concentrates (kilograms) | Values ($) |
|---|---|---|
| 1978-84 | - | - |
| 1977[1] | 30 400 | .. |
| 1976[1] | 26 308 | .. |
| 1975[1] | 34 927 | .. |
| 1974 | 39 366 | .. |
| 1973 | .. | .. |
| 1972 | - | - |
| 1971 | .. | .. |
| 1970 | 33 112 | 657,000 |
| 1969 | 38 756 | 671,500 |
| 1968 | 51 406 | 936,067 |
| 1967 | 78 268 | 1 594,298 |
| 1966 | 9 400 | 130,223 |

Source: Statistics Canada.

[1] Annual Reports, Denison Mines Limited.

.. Not available; - Nil.

# Rhenium

W. McCUTCHEON

The major end-use for rhenium is as one of the components of a bimetallic catalyst used in the production of low lead and lead-free gasolines. In petroleum refineries, bimetallic rhenium-platinum (Re-Pt) catalysts are usually found to be more economical to use than monometallic platinum catalysts. As most refineries have already switched to Re-Pt catalysts, future growth in this important market is likely to be much less than in the preceding decade.

## CANADIAN DEVELOPMENTS

Island Copper Mine is the sole producer of recoverable rhenium in Canada. Island Copper is owned by Utah Mines Ltd., a subsidiary of Utah International Inc. which is a division of The Broken Hill Proprietary Company Limited of Australia.

Island Copper, a copper molybdenum operation, near Port Hardy, Vancouver Island, British Columbia began production in 1972. The ore occurs mainly in altered volcanic rocks and in this respect differs from the porphyry copper deposits which have been the major source of rhenium in the United States and Chile.

Until late 1983, the rhenium contained in the concentrates was treated at the smelters on a toll basis and the recovered rhenium was returned to the company as perrhenic acid for subsequent upgrading and sale. Since 1984, Island Copper has sold the rhenium contained in the molybdenite concentrates.

The production of rhenium from Island Copper is a function of the rhenium content of the molybdenite, the quantity of molybdenite mined and the mill recoveries of molybdenite and rhenium. With present technology, the recovery of rhenium contained in the molybdenite concentrates ranges from about 50 to 60 per cent.

Rhenium has also been identified in the porphyry copper ores of Lornex Mining Corporation Ltd. and Brenda Mines Ltd. in British Columbia. Future recovery of rhenium from these operations is unlikely, given expected future rhenium prices.

Canadian consumption data is not collected. However, the consumption pattern is believed to follow that of the United States, with rhenium-platinum (Re-Pt) catalysts accounting for the vast majority of consumption.

## WORLD DEVELOPMENTS

The only known commercial sources for rhenium are molybdenum concentrates recovered from the treatment of low-grade porphyry copper ores and from sedimentary copper deposits in the U.S.S.R. The rhenium content of the copper porphyry ores is relatively low, being only a few parts per million (ppm), whereas the molybdenite concentrates produced from these ores have a rhenium content ranging from 300 to 2 000 ppm. Rhenium has also been identified in certain platinum group metals and ores of manganese, tungsten and uranium, but in concentrations too low to be of economic significance under the present technology and price structure.

As rhenium is produced as a byproduct of copper mining, its production depends upon copper markets, and no operation will increase copper and molybdenum production merely to obtain more rhenium.

Rhenium production statistics are not available for the United States. World production outside the United States is estimated by the United States Bureau of Mines (USBM) to be about 13 550 kg in 1982, 11 250 kg in 1983 and 8 750 kg in 1984.

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In the United States, there are five plants which can recover rhenium. It is believed that plants owned by Kennecott Corporation near Salt Lake City, M&R Refractory Metals, Inc. in New Jersey and Molycorp, Inc. in Pennsylvania did not operate in 1983 or 1984. S.W. Shattuck Chemical Co., Inc. in Denver operated in 1983 and Duval Corporation is believed to have recovered rhenium at its Sierrita property in Arizona in 1984. Some of the rhenium recovered by Shattuck in 1982 and 1983 was material toll refined for Utah from its Island Copper mine. Very low copper and molybdenum prices have resulted in many mine closures in the United States and hence reduced mine production of contained rhenium.

Chile, which has become the world's largest copper producer, was reported by the USBM to be the largest market economy producer of rhenium with a 1983 production of about 3 180 kg. Chilean rhenium mine production from the Corporacion Nacional del Cobre de Chile (Codelco) is estimated by the USBM to be about 2 400 kg in 1984. Prior to 1974, rhenium exported from Chile was contained in molybdenite concentrates shipped for treatment to the United States and elsewhere. In 1974, Chile began to export ammonium perrhenate to the United States. Since 1979, Codelco has had a tolling contract with Molibdenos y Metales S.A. (Molymet) for the recovery of rhenium.

Rhenium is recovered from copper porphyries mined in Iran, Peru, U.S.S.R., Canada, United States and Chile. In the case of the U.S.S.R., some rhenium is recovered from the Dzhezkazgan sedimentary copper deposit in Kazakhstan. Small amounts of rhenium has been produced in the past by Zaire, Bulgaria, Democratic Republic of Germany and Poland.

Besides the United States and Chile, countries which have metallurgical plants for the recovery of rhenium are the U.S.S.R., Sweden, France, the United Kingdom and the Federal Republic of Germany. With the exception of the U.S.S.R., these countries recover rhenium from imported molybdenite concentrates.

Chile is believed to be the largest exporter of rhenium in the form of ammonium perrhenate. The Federal Republic of Germany is believed to be the largest exporter of rhenium in metal form. The United States is the largest importer of rhenium in both forms.

Complete world consumption data are not available, however, the United States is believed to be the largest rhenium consumer accounting for an estimated 2 680 kg in 1982, 4 000 kg in 1983 and 4 100 kg in 1984.

## USES

The primary use of rhenium is for Re-Pt catalysts which are used in the production of low lead and lead free high octane gasolines. About 90 per cent of the United States consumption is taken in this use. Other uses for Re-Pt catalytic include production of toluene, benzene and xylene.

The bimetallic Re-Pt catalyst (generally 0.3 per cent Re, 0.3 per cent Pt, 99.4 per cent alumina) generally gives superior performance compared to monometallic platinum catalysts: it can be easily regenerated, is more productive, tolerates greater impurity levels and has a longer life. Hence it has steadily replaced most monometallic catalysts used in petroleum refining since commercial introduction in 1969.

Other applications for rhenium include use in filament alloys, heating elements, electrical contacts, metallic coatings high temperature nickel alloys, and as an alloy with tungsten for use as a catalyst to oxidize $SO_2$ to $SO_3$ for the manufacture of sulphuric acid.

## TECHNOLOGY

Rhenium is recovered from flue gases emitted from the roasting of byproduct molybdenite concentrates. Under properly controlled temperature, rhenium volatilizes as rhenium heptoxide ($Re_2O_7$), a compound which is readily soluble in an aqueous solution and can be recovered by subjecting flue gases to wet scrubbing. The rhenium is extracted from this solution as ammonium perrhenate ($NH_4ReO_4$) by ion-exchange resins or by solvent extraction. Perrhenic acid ($HReO_4$) is also an important commercial product of rhenium. Rhenium metal (99.99 per cent pure) is produced by the reduction of ($NH_4ReO_4$) with hydrogen to produce rhenium powder. The powdered form is pressed and sintered into bars which are cold-rolled to form different shapes. The cost of producing rhenium metals and salts is high. Research has been directed toward the development of a hydrometallurgical process to recover molybdenum and rhenium from molybdenite concentrates in order to attain a higher rate of recovery and lower costs of production.

## PRICES

Rhenium prices rose from a fairly stable base of about $US 600/lb through the 1960s and 1970s to over $US 2,500/lb in May 1980. Prices for the metal averaged $US 410 in 1982, decreased from $US 350 to $US 250/lb in 1983 and are estimated at an average of $US 300/lb for 1984. Prices for the rhenium content in perrhenic acid averaged $US 375 in 1982, decreased from $US 300 to $US 200/lb in 1983 and are estimated at an average of $US 2C0/lb in 1984.

## OUTLOOK

Rhenium has been used as an industrial metal for a short period and has not developed a clearly defined growth pattern. The limited supply of rhenium inhibits development of new uses with widespread applications. The potential supply of the metal is limited to the rhenium contained in byproduct molybdenite concentrates obtained from porphyry copper ores. Under present technology, the overall recovery of molybdenite from the processing of copper ores varies considerably but is relatively low. The recovery of rhenium from the treatment of molybdenite concentrates is about 60 per cent. Any improvement in the recovery rate in either of these areas would increase the supply of available rhenium. Canadian rhenium production is likely to continue until the early 1990s at which time Island Copper's ore will have been depleted.

Not all molybdic oxide producers recover rhenium from the treatment of byproduct molybdenite concentrates due to the high capital costs involved in building a recovery plant. These molybdic oxide operations are potential new sources of rhenium, given a stable price pattern that would justify committing funds for the construction of a recovery plant.

In the short-term, the major use of rhenium will continue to be in bimetallic platinum-rhenium catalysts in the petroleum refining industry. Use in this application could increase as more stringent standards for automotive emissions are introduced reducing the use of tetraethyl lead in gasoline.

Future growth of rhenium demand for petroleum refining is expected to be much less than the rate of the 1970s, due to saturation of the market and technical advances which extend catalyst life and permit high rates of recycling. Future successful technical advances in the development of alternative catalysts could result in substitution away from Re-Pt catalysts. Demand would also be lowered by use of low octane gasoline engines, increased market share of diesel powered automobiles, new octane improving additives.

In the long-term, metallurgical applications for rhenium probably have greater growth potential than do catalytic applications. Iridium, gallium, germanium, indium, selenium, silicon, tin, tungsten and vanadium may all be replaced by rhenium under certain conditions. Rhenium is highly refractory, having a melting point of 3 180°C, second to that of tungsten, and maintains strength and ductility at high temperatures. Its density of 21 grams per cubic centimetre ($g/cm^3$) is exceeded only by that of the platinum-group metals. Rhenium has good corrosion resistance to halogen acids. Alloyed with tungsten or molybdenum, rhenium improves the ductility and tensile strength of these metals. Stable oxide film on rhenium does not appreciably increase electrical resistance and this property, plus good resistance to wear and arc corrosion, makes the metal ideally suited for electrical contacts.

## TABLE 1. CANADIAN RHENIUM STATISTICAL DATA, 1982-1984

| | 1982 | 1983 | 1984e |
|---|---|---|---|
| Rhenium content of Island Copper's molybdenite concentrates (ppm)[1] | 1075ppm | 1175ppm | 1250ppm |
| Shipments of molybdenite concentrates[2] | | | |
| United States | 757t | - | - |
| Federal Republic of Germany | 1869t | 2898t | 1701t |
| Chile | 1320t | 762t | 1696t |
| United Kingdom | 45t | 36t | - |
| Total[3] | 3992t | 3697t | 3397t |
| Average price[4] | $US550/lb | $US390/lb | $US30-35/lb |

Sources: Utah Mines Ltd.; Energy, Mines and Resources.
[1] Rounded to nearest 25 ppm; [2] Dry tonnes; [3] Totals may not add due to independent rounding; [4] Price for ammonium perrhenate in 1982 and 1983; price for rhenium content contained in molybdenite concentrates in 1984.
e Estimated; - Nil.

# Salt

M. PRUD'HOMME

## SUMMARY

Canada produces rock salt from four salt mines and as byproduct from two potash mines. Brine, which accounts for 23 per cent of total production, is produced in 12 plants where it is used to manufacture table salt or chloralkali chemicals.

Production of salt from all sources rose to 8 591 000 t in 1983, and is expected to reach 10 294 000 t in 1984. Increases are mainly due to completion of expansion of the Domtar mine at Goderich, Ontario, and to the operational level of production at Mines Seleine Inc. on Madeleine Islands.

In 1983, the average value of salt in all forms is estimated at $20.28 per t, compared to $19.73 in 1982. Consumption increased mainly in the industrial chemicals sector which has benefitted from an anticipated improvement in the manufacturing sector, namely construction, automobile and the pulp and paper industry. Road de-icing rock salt shipments recorded a slight drop because of high inventories left behind as a result of the mild winter of 1983.

Net exports reached record levels in 1983 with an increase of 98 per cent in current value from 1982. It totalled around $12,988,000. Exports to the United States increased by 11 per cent in tonnage, in 1983, after a 13 per cent rise in 1982. Imports are 57 per cent from the United States, mainly rock salt, and 33 per cent from Mexico, mainly solar-evaporated salt. The latter is classified as wet salt in bulk, with 2 to 6 per cent moisture content.

## DOMESTIC PRODUCTION AND DEVELOPMENTS

**Atlantic region.** Salt deposits occur in isolated sub-basins of a large sedimentary basin that underlies the northern mainland of Nova Scotia and extends westward under the bordering areas of New Brunswick, northeastward under Cape Breton Island, Prince Edward Island, the Madeleine Islands and southwestern Newfoundland. The salt beds occur within the Mississippian Windsor Group and are generally folded and faulted. The deposits appear to be steeply dipping tabular bodies, domes and brecciated structures of rock salt.

Salt production in the Atlantic provinces is from an underground rock salt mine at Pugwash in Nova Scotia, an underground potash and salt mine at Sussex in New Brunswick and a brining operation near Amherst in Nova Scotia.

In New Brunswick, Potash Company of America (PCA) started a $150 million development plan in 1981 to produce potash with salt as byproduct. The mine, located at Plumweseep near Sussex, commenced production in July 1983 and is expected to reach 900 000 tpy of potash. Salt will be extracted at a rate of 400 000 to 500 000 tpy and will be sold mainly to the eastern United States. Reserves are estimated large enough to operate for at least 20 years. Salt is marketed for road de-icing and chemical plants, and in 1983, it was distributed by the International Salt Company, United States, or its Canadian subsidiary, Iroquois Salt Products Ltd.

Denison-Potacan Potash Company produced small amounts of salt from its potash mine now under development at Salt Springs near Sussex. Completion of the project is due in mid-1985. However, the company is not expected to become a regular producer of salt after completion of construction.

In Nova Scotia, the Canadian Salt Company Ltd. operates an underground rock salt mine at Pugwash in Cumberland county, with a rated capacity of nearly 1 000 000 t. Most of the salt is used for snow and ice control, while some high purity salt is dissolved for vacuum pan evaporation and sold for high quality applications including table salt. In 1984, an agreement was signed between the provincial departments

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and the Canadian Salt Company Ltd. to upgrade the 14-mile highway route from the mine to the TransCanada Highway. The project will cost $2.7 million and will allow trucks to carry 35 tonne-loads. The project is to be completed by the summer of 1985.

Domtar Chemicals Group has a brining operation at Nappan in Cumberland County. This company has announced, in 1984, a $9.5 million modernization plan, with assistance from the Canadian program of Atlantic Energy Conservation Investment. A $3.4 million contribution will go towards replacement of the present multi-stage evaporators with a single thermocompression evaporator, and the existing top-feed filter dryer by a centrifuge and fluidized bed dryer. Completion of the project is due in January 1986, and is expected to generate substantial energy savings. Meanwhile, Domtar Inc. continues to hold its salt development licence at Kingsville in Inverness County.

In 1984, exploration and development programs have examined salt structures in the Canso Strait area of Cape Breton Island for underground gas storage: Gulf Canada in the McIntyre area of Inverness County and Dow Chemicals at Lower River Inhabitant and at Port Richmond in Richmond County.

**Quebec.** A salt deposit located on the Archipelago of the Madeleine Islands, in the Gulf of St. Lawrence, is part of the Mississippian Carboniferous Basin. Discovered in 1972, the Rocher-aux-Dauphins deposit is characterized by thick sequences of commercial salt, large sequences of rythmic salt and anhydrite cycles, abundance of low grade potash horizons and some clay. The deposit is a typical piercement salt diapir generated by upward movements of the salt from the underlying anticlinal structure. It contains about 4 billion t of raw salt of which a quarter is above 97 per cent sodium chloride. The salt lies between 30 m and 75 m underneath the surface. The deposit dips about 55 degrees to the southwest. Reserves are 460 million t of which 34.2 per cent are mineable, grading an average of 94.5 per cent NaCl.

Mines Seleine Inc., a subsidiary of Société québécoise d'exploration minière (SOQUEM) mines rock salt commercially since the spring of 1983. This underground operation has a production capacity of 1.23 million tpy, and reserves are sufficient for 20 years.

In 1983, salt production for de-icing purposes has reached 640 443 t. In 1984, production is expected to be 1 million t. Full capacity of production could be achieved by 1986.

In October 1983, the Port of Montreal bought land in Montreal-East for storage and handling of salt from Mines Seleine Inc. The Canadian government purchased the land for $1.4 million and leased it to Mines Seleine Inc. under a long-term contract.

In 1984, a 10-year contract was signed with the Department of Highways of the Quebec Government to supply nearly 90 per cent of their salt requirements. Navigation Sonamar Inc. will provide the service of a 19 000 t capacity ship, M.V. Saunière, under contract until 2002. Underground work has been completed to improve grinding and sizing operations, and to increase the storage capacity to 25 000 t. Current activities involve moisture control to reduce local condensation, and ventilation to provide good environmental working conditions. Mines Seleine Inc. employs 190 persons at the mine site.

The shipping season is 270 days, from April 1 to December 31. All salt produced is for de-icing purposes and is shipped to mainland Quebec, Newfoundland and northeastern United States. In the long-term, investments will be required to control the moisture content in the mine, to improve access to port facilities and to increase surface storage at the mine site.

**Ontario.** Thick salt beds underlie much of southwestern Ontario, extending from Amherstburg northeastward to London and Kincardine, bordering on what is known geologically as the Michigan Basin. As many as six salt beds, occurring in the Upper Silurian Salina Formation at depths from 275 to 825 m, have been identified and traced from drilling records. Maximum bed thickness is 90 m, with aggregate thickness reaching as much as 215 m. The beds are relatively flat-lying and undisturbed, resulting in low-cost mining.

During 1984, those beds were worked through two rock salt mines, one at Goderich and one at Ojibway, and through brining operations at Goderich, Sarnia, Windsor and Amherstburg.

At Goderich, Domtar Chemicals Group operates an underground rock salt mine.

Since September 1983, an expansion plan has been completed, and the opening of the third shaft is expected to increase production by 55 per cent, from 2 million tpy to 3.15 million tpy. Employment will increase from 275 to 350. The two-year expansion will cost nearly $40 million. Between 60 and 70 per cent of rock salt is used for de-icing, the balance by the chemical industry and for water softening. Domtar Inc. also has a brining operation for production of special salt products. The Canadian Department of Transport has announced in August 1984 that it will proceed with a $17 million harbour development project over the next three years to enhance shipping capabilities of the Port of Goderich.

At Sarnia, Dow Chemicals of Canada Ltd. produces brines from wells for the production of caustic soda and chlorine.

At Windsor, the Canadian Salt Company Ltd. produces both rock salt from an undergound mine near Ogibway and vacuum salt products from brine wells having a total rated capacity of more than 2 million tpy. Installation of new silo facilities to improve salt storage and distribution has been completed in 1984.

In the vicinity of Amherstburg, Allied Chemical Canada Limited operates a brining operation for the manufacture of soda ash and byproduct calcium chloride by the Solvay process.

**Prairie Provinces.** Salt beds underlie a broad belt of the Prairie Provinces extending from the extreme southwestern corner of Manitoba northwestward across Saskatchewan and into the north-central part of Alberta. Most of the salt deposits occur within the Prairie Evaporite Formation, which constitutes the upper part of the Middle Devonian Elk Point Group, with thinner beds of salt occurring in Upper Devonian rocks. Depths range from 180 m at Fort McMurray, Alberta, to 900 m in eastern Alberta, central Saskatchewan and southwestern Manitoba, and to 1 830 m around Edmonton, Alberta, and in southern Saskatchewan. Cumulative thicknesses reach a maximum of 400 m in east-central Alberta. The beds lie relatively flat and undisturbed. The same rock sequence contains a number of potash beds currently under exploitation in Saskatchewan.

In Saskatchewan, four companies produce salt from the Middle Devonian Praries formation. International Minerals and Chemical Company (Canada) Limited supplies byproduct rock salt from its potash operation at Esterhazy. Its salt is distributed locally for road de-icing by Kleysen Transport Company. Domtar Inc. operates a brining operation, near Unity, for the production of fine vacuum-pan salt and fusion salt. The Canadian Salt Company Ltd. at Belle Plaine uses byproduct brine from an adjacent potash solution mine owned by PPG Industries Canada, a division of Kalium Chemicals Limited, to extract table salt. Saskatoon Chemicals Company, a division of Prince Albert Pulp Company Ltd., produces brines from wells near Saskatoon for the manufacture of caustic soda and chlorine, mainly used by pulp producers as a bleaching agent.

In Alberta, two producers operate brining operations: at Fort Saskatchewan near Edmonton, Dow Chemical Canada Inc. produces salt brine for the manufacture of chloralkali chemicals; and, at Lindberg, the Canadian Salt Company Ltd. produces fine vacuum pan salt and fusion salt.

**British Columbia.** There is no production of salt in this province where four companies operate six chloralkali plants: B.C. Chemicals Ltd. in Prince George, ERCO Industries Limited in North Vancouver, FMC of Canada Limited at Squamish and Canadian Occidental Petroleum Limited in North Vancouver, Squamish and Nanaimo. Raw materials are imported from Mexico and the United States.

## CANADIAN CONSUMPTION AND TRADE

The salt consumption pattern in Canada is quite different than in the rest of the world. The largest single utilization, for the past five years, has been for snow and ice control. This usage is principally confined to North America and Europe.

Consumption varies from year to year depending on weather conditions and this market is expected to increase marginally over the next decade. For the past eight years, the average proportion for this purpose in Canada was about 45 per cent of total consumption, compared to 20 per cent for the United States and 14 per cent in western Europe. On a world basis, this application accounts for 10 per cent of total world salt consumption. For road de-icing, the American Society for Testing and Materials (ASTM) provides standard specifications for sodium chloride: D632-72 (78). Rates of application are controlled by several factors such as precipitation, temperature, wind effects, traffic density and road conditions. Practices for such usage also include utilization of mixtures with calcium chloride or sand and gravel as abrasive components.

The next largest consumer of salt is the industrial chemicals industry, particularly for the manufacture of chloralkalis, namely caustic soda (sodium hydroxyde), chlorine and soda ash (sodium carbonate). Salt for four caustic soda and chlorine plants in Canada is obtained from on-site brining and natural brines; others use mined rock salt or imported solar-evaporated salt. The chemical industry accounts for over 60 per cent of total world consumption of salt while, in Canada, it has averaged 45 per cent for the past five years. Chlorine is largely used by the plastic industry and as a bleaching agent for the manufacture of bleached pulp and newsprint. The principal uses for caustic soda are in the manufacture of organic and inorganic chemicals, pulp and paper, alumina and textiles. The glass industry is a major user of soda ash. Other industrial chemicals that require significant quantities of salt include sodium chlorate, sodium bicarbonate, sodium chlorite and sodium hypochlorite. The ASTM standard method E-534-75 covers the analytical procedures for chemical analysis of sodium chloride. Strong growth in this market is expected to continue based on domestic demand as well as on export opportunities.

Other consumption areas for salt include the food industry, animal diet, fishery industry and water treatment which all account for less than 10 per cent of total Canadian consumption. Slight growth in these markets should continue in the short-term, although there is some pressure to use less salt for health reasons in the food industry.

The pattern of Canada's salt trade has changed drastically in terms of volume in the past two years. In 1983, Canada exported twice as much as it imported; the United States remained our major trade partner taking 99 per cent of our exports and accounting for 57 per cent of our imports. Mexico accounts for 33 per cent of our imports, especially solar-evaporated salt for chemical plants in British Columbia. Spain and Portugal are our main sources of supply for salt consumed by the fish industry, namely in Newfoundland and Nova Scotia.

Because of its low unit value and availability in most key market areas, salt is seldom hauled over long distances, except in the case of seaborne and intercoastal shipment where longer routes entail little additional cost. Increased capacity in eastern Canada (Ontario, Quebec and New Brunswick) will likely replace salt traditionally imported from Mexico and the northeastern United States. The trade surplus (exports less imports) totalled $12,988,000 in 1983, compared to only $798,000 in 1982.

## WORLD PRODUCTION AND SITUATION

In 1983, world production of salt has increased by 0.04 per cent to 165 760 000 t despite a 9 per cent drop in salt production in the United States which accounts for nearly 20 per cent of the world total. The American decline was mainly due to lower demand for de-icing rock salt as a result oflarge purchases and stocks in 1982.

**United States:** In 1983, International Salt Co. placed its evaporative salt plant refinery at Avery Island in Louisiana on an indefinite stand-by and its rock salt plant in Detroit, Michigan, was idle most of the year. Diamond Crystal Salt Co. accepted a $32 million settlement for the flooding of its Jefferson's Island rock salt mine, in 1980.

In 1984, Cargill Inc. closed permanently its 1.5 million tpy Belle Isle's rock salt mine at Patterson, Louisiana; it has also announced plans to construct a new solar salt facility by 1985, with a production capacity of about 200 000 tpy, near Freedom, Oklahoma. Morton Thiokol Inc., at Weeks Island in Louisiana, will increase its production of rock salt mine by more than 300 000 tpy, and announced, in August 1984, its intention to close for 3 months its salt plant located in Marysville, Michigan, reducing the output by more than 50 per cent.

Diamond Crystal Salt Co., near St-Clair in Michigan, signed a letter of intent to purchase American Salt Co., a subsidiary of General Host Corp., for $40 million. The purchase is to include a rock salt mine and an evaporated salt facility in Lyons, Kansas, and a solar salt facility near Salt Lake City, Utah. In the summer of 1984, American Salt Co. was found liable in U.S. District Court for damages involving salt pollution of an aquifer in Kansas.

**China:** Salt deposits have been discovered in the Qamdo prefecture. Reserves are estimated at 90 million t of salt grading 30 per cent of sodium chloride as well as some potassium chloride.

**Thailand:** ASEAN Soda Ash Co. Ltd. reported plans to build a 400 000 tpy soda ash plant which would require 600 000 tpy of rock salt. Mine development at Bambet Narong in Chaiyaphum Province would take 3 years and investment would be in the range of $32-37 million.

**Yugoslavia:** A salt deposit with estimated reserves of 400 million t has been discovered near Tulza.

## PRICE

Salt is not a standard commodity and its price ranges widely depend on such factors as production methods, purity, scale of operations and transportation costs.

In 1984, Canadian rock salt prices, fob works, for de-icing purposes varied from $21.00 to $41.00 per t.

## OUTLOOK

Canada is nearly self-sufficient in salt. Eastern Canadian requirements of rock salt are served locally while imports serve western needs for chloralkalis plants in British Columbia. Current capacity should be sufficient to meet any forecast increase in demand for the next decade. Growth for world production has been estimated at 2 per cent up to 1990.

Consumption of salt in Canada is largely based on two sectors: ice and snow control and industrial chemicals which account together for 90 per cent of the total Canadian consumption.

Road salt de-icing demand should remain stable for the next few years. This usage is highly seasonal but several factors mitigate against any significant increase: slowdowns in road construction, application optimization and environmental considerations. Thus, a slow growth of not more than 1 per cent per annum is forecast for this purpose.

The industrial chemicals industry is definitely the sector which will see some growth in the decade. Chlorine production reached 1 385 000 t in 1983, a 12 per cent increase over 1982. The major share of this rise was in polyvinyl chloride (PVC) production, which rose by 26 per cent from the 1982 level. Chlorine demand is oriented to PVC usage in the construction and automotive sectors, and as a bleaching agent in the pulp and paper industry, the latter accounting for 41 per cent of consumption. Construction of new houses affects demand for PVC pipes and tubing. Up to 1990, a modest growth of 0.2 to 0.6 per cent in residential construction is expected while the non-residential sector should grow at between 4.8 and 6.5 per cent a year. In the automobile industry, the share of plastics in standard American cars is forecast to grow at 9.2 per cent for the period 1981-92; since, automobile demand is expected to grow at a rate of 1.8 to 2.6 per cent in North America for the next five years. The net result should be a greater demand for salt used in these products.

Consumption of chlorine in the pulp and paper industry in 1983 was 480 000 t, an increase of 4 per cent compared to 1982. It should reach about 510 000 t in 1984. However, chlorine producers are reluctant to expand capacity because pulp mills may not increase future purchases as chlorine dioxide bleaching continues its penetration of the chlorine market in paper mills.

Caustic soda markets continued to be saturated in Canada. In 1983, production amounted to 1 528 000 t which is much in excess of domestic needs, estimated at 900 000 t in the pulp and paper industry; exports rose by 33 per cent to reach 228 000 t in 1983. Anticipated recovery in pulp production should result in stronger demand for caustic soda and chlorine for 1984-85. Long-term projections suggest a growth in the range of 2 to 3 per cent for caustic soda and 2 per cent for chlorine.

Sodium chlorate is used in the manufacture of chlorine dioxide. Supply continues to increase as new capacity is projected, especially in Quebec where favorable power rates will permit low-cost production. Canadian production in 1983 was about 294 000 t, of which nearly 196 000 t was consumed in the pulp and paper industry. Canadian exports amounted to 98 000 t in 1983. North American market growth is expected at 2 to 4 per cent per annum over the next decade.

For 1984, the Canadian Pulp and Paper Association has foreseen an 8 per cent rise in overall pulp and paper shipments. Most mill chemicals should show a growth of 5 to

10 per cent in 1984. Corporate investment intentions have been projected to exceed $3 billion over the next few years. Such projects associated with increased production will result in an increase in demand for industrial chemicals, such as caustic soda and sodium chlorate. Chlorine would benefit from this expected growth as well as in the construction and automobile sectors.

Other end-use markets such as animal feeds, human foods and water treatment will likely display slight but steady growth in the short-term, based on population growth.

**TARIFFS**

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| CANADA | | | | | |
| 92501-1 | Common salt (including rock salt) | free | free | 5¢/100 lb | free |
| 92501-2 | Salt for use of the sea or gulf fisheries | free | free | free | free |
| 92501-3 | Table salt made by the admixture of other ingredients when containing not less than 90 per cent of pure salt | 4.6 | 4.5 | 15 | 3 |
| 92501-4 | Salt liquors and sea water | free | free | free | free |

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| MFN Reductions under GATT (effective January 1 of year given) | | | | | | |
| 92501-3 | | 4.5 | 4.4 | 4.3 | 4.1 | 4.0 |
| UNITED STATES, Customs Tariffs (MFN) | | | | | | |
| 420.92 | Salt in brine | 4.4 | 4.2 | 4.0 | 3.9 | 3.7 |
| 420.94 | Salt in bulk | 1.5 | 1.1 | 0.8 | 0.4 | free |
| 420.96 | Salt, other | Remains free | | | | |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1983), USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241.

**TABLE 1. CANADA, SALT PRODUCTION AND TRADE, 1982-84**

| | 1982 | | 1983P | | 1984e | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($) | (tonnes) | ($) | (tonnes) | ($) |
| **Production** | | | | | | |
| By type | | | | | | |
| Mined rock salt | 5 265 622 | .. | 5 843 000 | .. | | .. |
| Fine vacuum salt | 762 850 | .. | 727 000 | .. | | .. |
| Salt content of brines used or shipped | 1 944 172 | .. | 2 021 000 | .. | | .. |
| Total | 7 972 644 | .. | 8 591 000 | .. | | .. |
| **Shipments** | | | | | | |
| By type | | | | | | |
| Mined rock salt | 5 223 073 | 84,901,020 | 5 842 000 | .. | .. | .. |
| Fine vacuum salt | 773 086 | 65,709,841 | 727 000 | .. | .. | .. |
| Salt content of brines used or shipped | 1 944 172 | 6,009,493 | 2 021 000 | .. | .. | .. |
| Total | 7 940 331 | 156,620,354 | 8 590 000 | 174,261,000 | 10 294 000 | 214,866,000 |
| By province | | | | | | |
| Nova Scotia | .. | .. | .. | .. | .. | .. |
| New Brunswick | .. | .. | .. | .. | .. | .. |
| Quebec | .. | .. | .. | .. | .. | .. |
| Ontario | 5 461 190 | 87,505,004 | 5 059 000 | 93,180,000 | 6 502 000 | 124,400,000 |
| Saskatchewan | 434 103 | 18,675,272 | 425 000 | 20,821,000 | 383 000 | 21,680,000 |
| Alberta | 862 969 | 15,281,324 | 1 195 000 | 15,071,000 | 1 237 000 | 18,254,000 |
| Total | 7 940 331 | 156,620,354 | 8 590 000 | 174,261,000 | 10 294 000 | 214,866,000 |
| **Imports** | | | | | (Jan.-Sept. 1984) | |
| Salt, wet in bulk | | | | | | |
| Mexico | 336 470 | 3,623,000 | 266 627 | 2,562,000 | 184 473 | 1,921,000 |
| United States | 36 066 | 440,000 | 11 207 | 136,000 | 183 744 | 2,705,000 |
| Total | 372 536 | 4,062,000 | 277 834 | 2,698,000 | 368 217 | 4,626,000 |
| Salt, domestic | | | | | | |
| United States | 8 819 | 1,033,000 | 7 956 | 994,000 | 7 280 | 931,000 |
| Switzerland | 54 | 18,000 | 141 | 29,000 | 26 | 19,000 |
| Netherlands | - | - | 128 | 4,000 | 1 | .. |
| Other countries | 4 | 2,000 | 52 | 8,000 | 44 | 8,000 |
| Total | 8 877 | 1,052,000 | 8 277 | 1,035,000 | 7 351 | 958,000 |
| Salt, nes | | | | | | |
| United States | 948 547 | 11,976,000 | 445 304 | 8,650,000 | 343 434 | 6,975,000 |
| Spain | 48 894 | 1,293,000 | 44 801 | 716,000 | 16 401 | 261,000 |
| Chile | 106 873 | 2,354,000 | 37 090 | 307,000 | - | - |
| Other countries | 41 152 | 540,000 | 944 | 94,000 | 39 771 | 529,000 |
| Total | 1 145 466 | 16,163,000 | 528 139 | 9,767,000 | 399 606 | 7,765,000 |
| Salt and brine by province of clearance | | | | | | |
| Newfoundland | 44 563 | 753,000 | 25 561 | 418,000 | 18 389 | 300,000 |
| Nova Scotia | 20 819 | 832,000 | 19 974 | 337,000 | 18 755 | 241,000 |
| New Brunswick | 34 | 1,000 | 47 | 7,000 | 46 | 24,000 |
| Quebec | 414 129 | 5,529,000 | 60 500 | 968,000 | 96 958 | 1,668,000 |
| Ontario | 543 993 | 7,123,000 | 269 531 | 4,642,000 | 349 541 | 6,059,000 |
| Manitoba | 785 | 73,000 | 2 755 | 182,000 | 2 342 | 152,000 |
| Saskatchewan | 1 160 | 93,000 | 2 606 | 206,000 | 2 296 | 227,000 |
| Alberta | 4 866 | 326,000 | 7 693 | 563,000 | 5 831 | 376,000 |
| British Columbia | 496 532 | 6,547,000 | 425 583 | 6,177,000 | 281 016 | 4,302,000 |
| Total | 1 526 879 | 21,277,000 | 814 250 | 13,500,000 | 775 174 | 13,349,000 |
| **Exports** | | | | | | |
| Salt and brine | | | | | | |
| United States | 1 717 973 | 21,735,000 | 1 908 385 | 25,754,000 | 1 867 074 | 21,189,000 |
| Guyana | - | - | 2 001 | 309,000 | 1 001 | 166,000 |
| Leeward-Windward Islands | 1 964 | 164,000 | 1 840 | 178,000 | 1 126 | 111,000 |
| Other countries | 1 956 | 176,000 | 2 383 | 247,000 | 1 549 | 31,000 |
| Total | 1 721 893 | 22,075,000 | 1 914 629 | 26,488,000 | 1 870 750 | 21,618,000 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; .. Not available; - Nil; nes - Not elsewhere specified; e Estimated.
Note: Totals may not add due to rounding.

TABLE 2. CANADA, SUMMARY OF SALT PRODUCING AND BRINING OPERATIONS

| Company | Location | Initial Production | Production[1] 1983P (1982) (000 tonnes) | Employment 1983P (1982) | Remarks |
|---|---|---|---|---|---|
| **Nova Scotia** | | | | | |
| The Canadian Salt Company Limited | Pugwash | 1959 | 667.5<br>(964.3) | 185<br>(216) | Rock salt mining to a depth of 253 m. |
| | Pugwash | 1962 | 83.4<br>(89.6) | | Dissolving rock salt fines for vacuum pan evaporation. |
| Domtar Inc. | Amherst | 1947 | 68.6<br>(72.4) | 74<br>(71) | Brining for vacuum pan evaporation. |
| **New Brunswick** | | | | | |
| Denison-Potacan Potash Company | Sussex | 1982 | 29.3<br>(56.1) | -<br>(-) | Salt from the development of a potash mine. |
| Potash Company of America | Sussex | 1980 | 377.4<br>(-) | 25[2]<br>(-) | A potash mine in operation since August 1983. Salt shipments resumed in February 1983. |
| **Quebec** | | | | | |
| Seleine Mines Inc. | Magdeleine Islands | 1982 | 617.5<br>(87.8) | 190<br>(150) | Production began in late 1982, mining to depth of up to 275 m. |
| **Ontario** | | | | | |
| Allied Chemical Canada, Ltd. | Amherstburg | 1919 | 518.3<br>(513.1) | 8[2]<br>(8) | Brining to produce soda ash. |
| The Canadian Salt Company Limited | Ojibway | 1955 | 1 784.7<br>(2 134.3) | 221<br>(256) | Rock salt mining at a depth of 300 m. |
| | Windsor | 1892 | 123.0<br>(121.6) | 132<br>(152) | Brining, vacuum-pan evaporation and fusion. |
| Domtar Inc. | Goderich | 1959 | 2 275.3<br>(1 906.0) | 323<br>(284) | Rock salt mining at a depth of 536 m. |
| | Goderich | 1880 | 108.1<br>(118.2) | 70<br>(63) | Brining for vacuum-pan evaporation. |
| Dow Chemical Canada Inc. | Sarnia | 1950 | 669.3<br>(667.6) | 5[2]<br>(5) | Brining to produce caustic soda and chlorine. |
| **Prairie Provinces** | | | | | |
| International Minerals & Chemical Corporation (Canada) Limited | Esterhasy, Sask. | 1962 | 88.7<br>(71.5) | 3<br>(3) | Byproduct rock salt from potash mine for use in snow and ice control. |
| The Canadian Salt Company Limited | Belle Plaine, Sask. | 1969 | 78.7<br>(77.4) | 24<br>(24) | Producing fine salt from byproduct brine from potash mine. |
| Domtar Inc. | Unity, Sask. | 1949 | 142.0<br>(165.5) | 85<br>(87) | Brining, vacuum-pan evaporation and fusion. |
| Saskatchewan Chemicals Co. | Saskatoon, Sask. | 1968 | 34.0<br>(34.0) | 5<br>(5) | Brining to produce caustic soda and chlorine. |
| The Canadian Salt Company Limited | Lindbergh, Alta. | 1968 | 118.3<br>(133.5) | 80<br>(65) | Brining, vacuum-pan evaporation and fusion. |
| Dow Chemical Canada Inc. | Fort Sask., Alta. | 1968 | 797.3<br>(792.5) | 3[2]<br>(8) | Brining to produce caustic soda and chlorine. |
| | | | 8 581.4<br>(8 005.4) | 1 433<br>(1 398) | |

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[1] Shipments; [2] Employment part of a chemical complex.
P Preliminary; - Nil.

**TABLE 3. CANADA, SALT SHIPMENTS, 1975, 1979-83**

| | Producers' Shipments | | | | | |
|---|---|---|---|---|---|---|
| | Mined Rock | Fine Vacuum | In Brine and Recovered in Chemical Operations | Total | Imports | Exports[1] |
| | | | (tonnes) | | | |
| 1975 | 3 626 123 | 578 649 | 1 291 489 | 5 496 261 | 1 183 144 | .. |
| 1979 | 4 934 574 | 735 460 | 1 645 914 | 7 315 948 | 1 276 179 | 1 822 120 |
| 1980 | 4 507 416 | 781 428 | 2 134 010 | 7 422 854 | 1 151 203 | 1 637 601 |
| 1981 | 4 371 314 | 764 037 | 2 107 243 | 7 242 594 | 1 254 992 | 1 507 710 |
| 1982 | 5 223 073 | 773 086 | 1 944 172 | 7 940 331 | 1 526 879 | 1 721 893 |
| 1983P | 5 842 000 | 727 000 | 2 021 000 | 8 590 000 | 814 250 | 1 914 629 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] As of the 1983 review Canadian Exports of salt will be reported in tonnes.
P Preliminary; .. Not available.

**TABLE 4. CANADA, AVAILABLE DATA ON SALT CONSUMPTION, 1980-1983**

| | 1980[r] | 1981[r] | 1982P | 1983[e] |
|---|---|---|---|---|
| | | (tonnes) | | |
| Snow and ice control[1] | 2 472 849 | 3 001 260 | 3 088 315 | 2 712 088 |
| Industrial chemicals[2] | 2 974 520 | 3 234 020 | 2 966 218 | 3 495 000 |
| Fishing industry | 65 000 | 68 000 | 83 000 | 64 000 |
| Food processing | | | | |
| Fruit and vegetable processing | 20 619 | 19 168 | 18 008 | 22 300 |
| Bakeries | 15 017 | 14 079 | 13 746 | 16 300 |
| Fish products | 24 296 | 33 983 | 33 582 | 35 200 |
| Dairy products | 13 056 | 10 740 | 10 447 | 12 900 |
| Biscuits | 1 892 | 2 022 | 2 082 | 2 600 |
| Miscellaneous food preparation | 46 587 | 24 874 | 22 680 | 36 000 |
| Grain mills[3] | 77 412 | 67 036 | 63 899 | 79 000 |
| Slaughtering and meat processors | 45 611 | 44 725 | 37 347 | 49 000 |
| Pulp and paper mills | 28 980 | 25 344 | 38 939 | 35 200 |
| Leather tanneries | 7 346 | 9 964 | 7 708 | 9 500 |
| Miscellaneous textiles | 2 924 | 2 664 | 2 871 | 3 400 |
| Breweries | 294 | 352 | 279 | 300 |
| Other manufacturing industries | 8 732 | 10 492 | 7 923 | 10 300 |
| Total | 5 805 135 | 6 568 723 | 6 397 044 | 6 583 088 |

Sources: Statistics Canada; Salt Institute.
[1] Fiscal year ending June 30. [2] Includes rock salt, fine vacuum salt and salt contained in brine. [3] Includes feed and farm stock salt in block and base forms.
[e] Estimated by Energy, Mines and Resources Canada; P Preliminary; [r] Revised.

TABLE 2. CANADA, SUMMARY OF SALT PRODUCING AND BRINING OPERATIONS

| Company | Location | Initial Production | Production[1] 1983P (1982) | Employment 1983P (1982) | Remarks |
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| | | | (000 tonnes) | | |
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| The Canadian Salt Company Limited | Pugwash | 1959 | 667.5<br>(964.3) | 185<br>(216) | Rock salt mining to a depth of 253 m. |
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| | Windsor | 1892 | 123.0<br>(121.6) | 132<br>(152) | Brining, vacuum-pan evaporation and fusion. |
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[1] Shipments; [2] Employment part of a chemical complex.
P Preliminary; - Nil.

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|---|---|---|---|---|---|---|
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| 1980 | 4 507 416 | 781 428 | 2 134 010 | 7 422 854 | 1 151 203 | 1 637 601 |
| 1981 | 4 371 314 | 764 037 | 2 107 243 | 7 242 594 | 1 254 992 | 1 507 710 |
| 1982 | 5 223 073 | 773 086 | 1 944 172 | 7 940 331 | 1 526 879 | 1 721 893 |
| 1983P | 5 842 000 | 727 000 | 2 021 000 | 8 590 000 | 814 250 | 1 914 629 |

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[1] As of the 1983 review Canadian Exports of salt will be reported in tonnes.
P Preliminary; .. Not available.

## TABLE 4. CANADA, AVAILABLE DATA ON SALT CONSUMPTION, 1980-1983

| | 1980r | 1981r | 1982P | 1983e |
|---|---|---|---|---|
| | | (tonnes) | | |
| Snow and ice control[1] | 2 472 849 | 3 001 260 | 3 088 315 | 2 712 088 |
| Industrial chemicals[2] | 2 974 520 | 3 234 020 | 2 966 218 | 3 495 000 |
| Fishing industry | 65 000 | 68 000 | 83 000 | 64 000 |
| Food processing | | | | |
| Fruit and vegetable processing | 20 619 | 19 168 | 18 008 | 22 300 |
| Bakeries | 15 017 | 14 079 | 13 746 | 16 300 |
| Fish products | 24 296 | 33 983 | 33 582 | 35 200 |
| Dairy products | 13 056 | 10 740 | 10 447 | 12 900 |
| Biscuits | 1 892 | 2 022 | 2 082 | 2 600 |
| Miscellaneous food preparation | 46 587 | 24 874 | 22 680 | 36 000 |
| Grain mills[3] | 77 412 | 67 036 | 63 899 | 79 000 |
| Slaughtering and meat processors | 45 611 | 44 725 | 37 347 | 49 000 |
| Pulp and paper mills | 28 980 | 25 344 | 38 939 | 35 200 |
| Leather tanneries | 7 346 | 9 964 | 7 708 | 9 500 |
| Miscellaneous textiles | 2 924 | 2 664 | 2 871 | 3 400 |
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| Other manufacturing industries | 8 732 | 10 492 | 7 923 | 10 300 |
| Total | 5 805 135 | 6 568 723 | 6 397 044 | 6 583 088 |

Sources: Statistics Canada; Salt Institute.
[1] Fiscal year ending June 30. [2] Includes rock salt, fine vacuum salt and salt contained in brine. [3] Includes feed and farm stock salt in block and base forms.
e Estimated by Energy, Mines and Resources Canada; P Preliminary; r Revised.

# Selenium and Tellurium

W.J. M$^{c}$CUTCHEON

Selenium is a nonmetallic element which is chemically similar to sulphur but which has some properties of a metal. Selenium occurs in minerals associated with sulfides of copper, lead and iron. Commercial production is principally from electrolytic copper refinery slimes as well as from flue dusts from copper and lead smelters. A significant amount of selenium is also recovered from secondary sources. In 1984, production and demand were estimated to be nearly in balance in the western world at about 1 540 tonnes (t) and 1 630 t, respectively. Large reductions of primary stocks in 1983 resulted in a rapid price rise in early 1984.

## CANADIAN DEVELOPMENTS

Selenium is recovered in Canada as a byproduct of the refining of blister copper and from the retreatment of recycled materials. Annual production (Table 1) is irregular, varying according to operating rates and recoveries at copper refineries and market conditions for selenium. Canadian production in 1983 and 1984 was affected by a ten-month shutdown at Inco Limited which ended in April 1983, by a 25 per cent production cut back at Noranda Inc.'s CCR refinery since mid-1984 and by variations in the content of selenium bearing feed to CCR. Xerographic scrap and other selenium scrap are imported from the United States and other countries to be refined in Canada and reexported. The total amount of selenium refined in Canada from both primary and secondary sources was 352 t in 1983 and is estimated at 450 t in 1984.

Noranda Inc.'s CCR Division copper refinery at Montréal East, Quebec, operates the largest selenium recovery plant in the world. The refinery handles blister copper from the company's Horne and Gaspé smelters in Quebec, from the Flin Flon smelter of Hudson Bay Mining and Smelting Co., Limited in Manitoba, and anode slimes from the copper refinery at KCML Inc. (formerly Kidd Creek Mines Ltd.). The selenium recovery unit produces commercial-grade (99.5 per cent) and high-purity (99.99 per cent) selenium and a variety of selenium compounds. Nominal annual capacity is about 325 t of primary selenium in elemental form and in salts, depending upon the selenium content of the blister copper processed. In addition, production capacity of secondary selenium is nominally 165 tpy, but this too depends upon the selenium content of the feed material. Due to extraordinarily high selenium contents of feed material, selenium recovery increased in 1984 over the 1983 level, although copper refining was reduced by 25 per cent at CCR in mid-1984.

Inco Limited's selenium recovery plant at Copper Cliff, Ontario treats tankhouse slimes from the company's Copper Cliff copper refinery. The capacity of the plant is 67 tpy of minus 200 mesh selenium powder (99.5 per cent Se). The Inco copper refinery reopened in April 1983, following a ten-month shutdown of the company's copper-nickel operations.

Canada consumes only a few per cent of its refined selenium production, mostly in the glass industry. Most selenium exports are to the United States and the United Kingdom with minor amounts to Europe. Shipments to Europe increased sharply in 1984.

## WORLD DEVELOPMENTS

Producing countries include the United States, Canada, Japan, the U.S.S.R., Belgium, Sweden, Mexico, Yugoslavia, Finland, Peru, Australia, and Zambia. Non-communist world reported production of refined selenium was 1 384 t in 1983 and increased to an estimated 1 357 t in 1984 (Table 2). A further 270 t was estimated to have been produced but not reported.

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As stocks of semi-processed anode slimes decreased from 227 t at the end of the first quarter 1983 to 116 tpy later, selenium production in the United States increased in 1983 to 354 t from 243 t in 1982. Primary selenium producers in the United States in 1983 were AMAX Copper, Inc., ASARCO Incorporated and Kennecott Corporation. Both domestic and imported material was processed in the United States. In 1984, Phelps Dodge Corporation became the fourth producer in the United States when the company's new selenium recovery facilities were started up at its El Paso, Texas refinery.

With the start-up of the Pasar copper smelter, the Philippines began to recover selenium in 1984. Production figures were unavailable but capacity is thought to be about 70 tpy.

Consumption of selenium in the western world in 1983 was reported at 1 440 t and estimated at 1 630 t for 1984. The United States is the most important consuming nation.

Apparent consumption of selenium in the United States in 1983 was 578 t up from 538 t in 1982. Estimated apparent consumption in 1984 was 570 t. According to the United States Bureau of Mines (USBM), the main end use by industrial categories in1983 were: electronic and photocopier components, 33 per cent; glass manufacturing, 27 per cent; pigments, 20 per cent; metallurgical applications, 7 per cent; other including animal feed and chemicals, 13 per cent.

The Selenium - Tellurium Development Association, Inc. (STDA) held its Third International Symposium on the industrial uses of selenium and tellurium in Sweden, during October. Papers discussing new applications, health issues and recent developments were presented.

## PRICES

Producer prices have not been published since early 1981. Metals Bulletin Inc. prints a "European Free Market" price spread for selenium. The mid-point of the spread averaged $US 4.07/lb in 1983, with a monthly average ranging from $US 3.41 to $US 3.48/lb. In 1984, the European prices increased to an average $US 6.34/lb in the first quarter, to $US 10.74/lb in the second quarter and decreased to $US 9.87/lb in the third quarter. The sharp price increase from $US 4.81/lb in February 1984 to $US 9.80/lb in March was likely a result of tight supplies resulting from the depletion of producer stocks in late 1983. Difficulties by merchants in obtaining supplies could also have contributed to the rapid price rise. The average European Free Market price for 1984 was estimated at $US 9.20/lb.

## USES

Selenium is used in the manufacture of glass, steel, electronic components, explosives, batteries, animal and poultry feeds, fungicides and pigments, and in xerography. The 1979 edition of this review contains a more detailed description of selenium uses.

The photoreceptor industry is the major user of selenium. Fully panchromatic organic photoreceptors and amorphorus silicon photoreceptors have the potential to substitute for selenium in new generations of photocopiers. While the final decisions have not been made with respect to which materials are the best photoreceptors for new processes, there is a possibility of a reduction in demand for selenium for its largest end use. Such a substitution, if it were to take place, is thought unlikely to affect selenium demand before the next decade.

Elemental selenium is marketed in two grades: commercial, with a minimum content of 99.5 per cent Se; and high purity, with a minimum content of 99.99 per cent Se. Other forms include ferroselenium, nickel-selenium, selenium dioxide, barium selenite, sodium selenate, sodium selenite and zinc selenite.

## OUTLOOK

Selenium is associated with copper minerals and hence its production is dependent upon primary copper production. EMR projects future copper consumption will increase at a rate of between 1.2 per cent and 1.6 per cent annually until the end of the century. The balance between sulfide and porphyry copper production is forecast to shift in favour of porphyry deposits. Porphyrys contain less selenium on average than do sulfide deposits and hence future mine selenium production will increase at a lower rate than the increase in copper mine production forecasted. Recoverable primary selenium production is likely to grow at a rate of about 1 per cent annually.

Given higher prices, production could be increased by improving selenium recovery from the present level of between 50 and 60 per cent. A minor increase in selenium recovery is also likely due to more stringent emission standards at copper and lead smelters.

Scrap supplies are a ready extra source of selenium in case of a significant price rise. Rectifier and xerographic scrap are two components of the estimated 200 to 400 t of scrap stocks which have accumulated.

New large scale uses for selenium in the long term are not predictable. Indeed while existing uses are unlikely to be threatened by substitution at existing prices in the medium term, technological advances such as a new photocopying process or the use of alternative photoreceptors have the potential to seriously reduce consumption. Such technical advances, like new large-scale uses, are difficult to predict.

The introduction of a major new use would be inhibited by the constraint upon supplies, as primary selenium production is a function of copper production. Although selenium recoveries could be improved and significant supplies of inventoried scrap could be processed to meet the increased demand, ultimately supply is constrained. Given significant sustained new demand, prices would rise encouraging the use of substitute materials.

Health related uses are likely to increase. Selenium is now added to vitamins tablets for humans, and to animal and poultry feeds. Selenium has also been studied as dietary cancer preventative agent.

Prices are likely to remain in the range of $US 10/lb in 1984 $US over the medium term. Significant price rises will be inhibited by the stocks of scrap selenium and market strategies of producers. Prices of $US 10/lb are thought to be insufficient to evoke reprocessing of the majority of existing scrap stocks. Much of the existing scrap inventories require a price of $US 15-20/lb before reprocessing is profitable. The long-term interests of major producers and consumers would not be best-served by large-scale price increases which encourage substitution away from selenium.

**TARIFFS**

CANADA

| Item No. | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|
| | | (%) | | |
| 92804-4 Selenium | 5 | 10 | 15 | 5 |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 92804-4 | 10.0 | 10.0 | 10.0 | 9.9 | 9.2 |

| UNITED STATES (MFN) | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 420.50 | Selenium dioxide | Remains free | | | | |
| 420.52 | Selenium salts | Remains free | | | | |
| 420.54 | Other selenium compounds | 4.4 | 4.2 | 4.0 | 3.9 | 3.7 |
| 632.40 | Selenium metal, unwrought, other than alloys, waste and scrap | Remains free | | | | |
| 632.88 | Selenium metal alloys, unwrought | 7.3 | 6.8 | 6.4 | 5.9 | 5.5 |
| 633.00 | Selenium metals, wrought | 7.3 | 6.8 | 6.4 | 5.9 | 5.5 |

| EUROPEAN ECONOMIC COMMUNITY (MFN) | | 1983 | Base Rate | Concession Rate |
|---|---|---|---|---|
| 28.04 C.2 | Selenium | free | free | free |

Sources: The Customs Tariff 1983, Revenue Canada Customs and Excise; Tariff Schedules of the United States Annotated (1983), USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 25, No. L318, 1982.

Tellurium, like selenium, is recovered in Canada from the tankhouse slimes from electrolytic copper refineries. It is refined by the same two companies who refine selenium: Noranda Inc.'s CCR Division at Montréal East, Quebec, and Inco Limited at Copper Cliff (Sudbury), Ontario. Although more "metallic" than selenium, tellurium resembles selenium and sulphur in chemical properties and, like selenium, is a semiconductor. Tellurium output is related to selenium output because tellurium is a coproduct of selenium recovery.

## CANADIAN DEVELOPMENTS

Refined production of tellurium was 23.5 t in 1983 and estimated at 15 t in 1984 (Table 5). The large difference between production (all forms) and refined production in some years is attributable to market conditions. Producers refine according to sales and can stockpile any surplus in less processed forms.

CCR Division has an annual capacity of up to 27.2 t of primary and secondary tellurium in powder, stick, lump and dioxide forms. The Copper Cliff refinery has an annual capacity of up to 8.2 t of tellurium in the form of dioxide (77 per cent Te).

In 1982, Cominco Ltd. built a $3 million plant at Trail, British Columbia to expand its production of mercury-cadmium telluride (MCT) in the form of single crystals. When sliced into thin wafers and polished, this compound is used in a wide range of electronic devices that detect infrared radiation to provide optical images or data. This plant is the only non-captive producer of such crystals and is the largest producer of high-purity detector grade tellurium.

## WORLD DEVELOPMENTS

Total refined world production is unavailable: Australia, U.S.S.R. and the Federal Republic of Germany do not report data, production data of the United States' single producer, ASARCO, is withheld for proprietary reasons, and data is insufficient to estimate production from Chile, Zaire and Zambia.

Apparent consumption in the United States increased from 46 t in 1982 to 57 t in 1983 to an estimated 90 t in 1984. Consumption in the United States had been higher (224 t in 1979) until a chemical plant in Texas closed in 1979. This plant had used a large quantity of tellurium as a catalyst for producing ethylene glycol (antifreeze) but experienced problems with its patented tellurium process.

## PRICES

Most of the commercial-grade tellurium sold by the primary producers is in the form of slab, stick, lump, tablet or powder. It is also sold in the form of copper-tellurium and iron-tellurium alloys. Normal commercial grades contain a minimum of 99 per cent or 99.5 per cent tellurium. Tellurium dioxide is sold in the form of minus 40 to minus 200-mesh powder containing a minimum of 75 per cent tellurium.

As a result of falling prices, producers suspended publication of tellurium prices on January 5, 1981. Prices in 1983 and 1984 are believed to have ranged between $US 8 and $US 14/lb, depending upon lot size, frequency of purchases and market conditions.

## USES

Tellurium supply is related to copper production but the nature of demand justifies only a low rate of recovery. Overexposure to tellurium could be hazardous to health, but fortunately tellurium imparts a disagreeable odor to the breath at low concentrations; this early warning signal has prevented any recorded toxic industrial exposures. Major uses are as additions to ferrous and nonferrous alloys to improve machineability or otherwise improve their metallurgical properties; however, bismuth is increasingly used as a substitute. Tellurium also performs an important role in the manufacture of rubber products, thermoelectric devices, catalysts, electronics, insecticides and germicides, delay blasting caps, glass, ceramics and pigments.

The consumption of tellurium in the United States by end use in 1983 was estimated by the USBM as: iron and steel products, 65 per cent; nonferrous metals, 17 per cent; chemicals including rubber manufacturing, 8 per cent; other, including xerographic and electronic applications, 10 per cent.

## OUTLOOK

Supply of tellurium is largely a function of copper output and new copper production is increasingly derived from tellurium-poor ores. In the short to medium term, demand is expected to grow slowly and supply should be adequate to meet requirements. However, as the total available supply of tellurium is even more limited than that of selenium, significant new uses of tellurium, such as in solar collectors, or in the form of MCT in photovoltaic cells could result in the higher prices that would justify a higher recovery from tellurium-bearing copper ores. Military and aerospace applications have the potential to increase MCT demand, presumpresumably even if prices were to rise significantly.

## TARIFFS

CANADA

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | | (%) | |
| 92804-5 | Tellurium | 5 | 10 | 15 | 5 |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 92804-5 | 10.0 | 10.0 | 10.0 | 9.9 | 9.2 |

| UNITED STATES (MFN) | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 427.12 | Tellurium salts | 4.4 | 4.2 | 4.0 | 3.9 | 3.7 |
| 421.90 | Tellurium compounds | 4.4 | 4.2 | 4.0 | 3.9 | 3.7 |
| 632.48 | Tellurium metals, unwrought other than alloys, and waste and scrap | 2.0 | 1.5 | 1.0 | 0.5 | free |
| 632.88 | Tellurium metal alloys, unwrought | 7.3 | 6.8 | 6.4 | 5.9 | 5.5 |
| 633.00 | Tellurium metal, wrought | 7.3 | 6.8 | 6.4 | 5.9 | 5.5 |

| EUROPEAN ECONOMIC COMMUNITY | | 1983 | Base Rate | Concession Rate |
|---|---|---|---|---|
| 28.04 C.3 | Tellurium metal | 2.3 | 2.4% | 2.1% |

Sources: The Customs Tariff 1983, Revenue Canada Customs and Excise; Tariff Schedules of the United States Annotated (1983), USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 25, No. L318, 1982.

### TABLE 1. CANADA, SELENIUM PRODUCTION, EXPORTS AND CONSUMPTION, 1982, 1983, 1984$^e$

| | 1982 | | 1983P | | 1984$^e$ | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Production** | | | | | | |
| Refined[1] | 234 | .. | 352 | .. | 448 | |
| **Exports** | | | | | | |
| United Kingdom | 47 | 451 | 111 | 1,236 | 99* | 1,825* |
| United States | 128 | 4,055 | 87 | 2,321 | 96* | 2,491* |
| Netherlands | 10 | 128 | 33 | 341 | 92* | 1,454* |
| P.R. China | - | - | - | - | 20* | 220* |
| Spain | 14 | 142 | 14 | 149 | 20* | 355* |
| Belgium and Luxembourg | 9 | 79 | 453 | 64 | 13* | 343* |
| Other countries | 6 | 239 | 9 | 398 | 18* | 608* |
| Total | 214 | 5,094 | 707 | 4,509 | 358* | 7,296* |
| **Consumption**[2] | 10.5 | .. | 11.8 | .. | .. | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Refinery output from all sources, including imported materials and secondary sources.
[2] Consumption (selenium content), as reported by consumers; other estimates put total consumption in Canada at over 15 t/y for 1982, 1983, 1984.
P Preliminary; .. Not available; - nil; * data for 9 months of exports in 1984, not total exports for the year.

### TABLE 2. CANADA, SELENIUM PRODUCTION, EXPORTS AND CONSUMPTION, 1970, 1975, 1980-84

| | Production Total Refined[1] | Exports[2] | Consumption[3] |
|---|---|---|---|
| | (tonnes) | | |
| 1970 | 388 | 311 | 7.1 |
| 1975 | 342 | 218 | 9.9 |
| 1980 | 377 | 307 | 10.8 |
| 1981 | 350 | 299 | 9.4 |
| 1982 | 234 | 214 | 10.5 |
| 1983P | 352 | 707 | 11.8 |
| 1984$^e$ | 448 | 358* | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Refinery output of selenium from all sources, including imported concentrates, blister and scrap and domestic scrap.
[2] Exports of selenium, metal powder, shot, etc.
[3] Consumption (selenium content), as reported by consumers.
P Preliminary; .. Not available; * data for 9 months of exports in 1984, not total exports for the year.

### TABLE 3. NON-COMMUNIST WORLD[1],[2] REFINERY PRODUCTION OF SELENIUM, 1982-84

| | 1982 | 1983 | 1984$^e$ |
|---|---|---|---|
| | (kilograms) | | |
| Japan | 410 | 433 | 400 |
| Canada | 234 | 352 | 448 |
| United States | 242 | 354 | 265 |
| Mexico | 29 | 30 | 30 |
| Sweden | 44 | 44 | 44 |
| Belgium and Luxembourg$^e$ | 60 | 60 | 60 |
| Other countries[3] | 111 | 111 | 110 |
| Subtotal[2] | 1 130 | 1 384 | 1 357 |

Sources: U.S. Bureau of Mines, Energy Mines and Resources Canada.
Notes:
[1] Includes material from primary plus secondary sources
[2] Australia, Federal Republic of Germany, and USSR refine selenium but do not report outputs. Estimates for these nations' outputs are not included in Table 3.
[3] Peru, Chile, Zambia, Finland and Yugoslavia
$^e$ estimates from USBM; other estimates are that Belgian production exceeds 100 t/y.

**TABLE 4. CANADA, INDUSTRIAL USE OF SELENIUM, 1980-82**

| | 1982 | 1983 | 1984 |
|---|---|---|---|
| | (tonnes of contained selenium) | | |
| By end-use[1] | | | |
| Glass | 7.0 | 8.5 | .. |
| Other[2] | 3.4 | 3.2 | .. |
| Total | 10.4 | 11.7 | .. |

[1] Consumption as reported by consumers
[2] Steel, pharmaceuticals.
.. Not available

**TABLE 5. CANADA, PRODUCTION AND CONSUMPTION OF TELLURIUM, 1970, 1975, 1978-84**

| | Production | Consumption |
|---|---|---|
| | Total Refined[1] | Refined[2] |
| | (tonnes) | |
| 1970 | 29.3 | 0.4 |
| 1975 | 42.3 | .. |
| 1978 | 45.3 | .. |
| 1979 | 47.2 | .. |
| 1980 | 9.0 | .. |
| 1981 | 21.3 | .. |
| 1982 | 16.5r | .. |
| 1983 | 23.5r | .. |
| 1984e | 15.0 | .. |

[1] Refinery output of tellurium from all sources, including imported concentrates, blister, and scrap and domestic scrap.
[2] Consumption (tellurium content), as reported by consumers.
.. Not available, withheld to avoid disclosing company data; e Estimated; r Revised.

**TABLE 6. IDENTIFIABLE NON-COMMUNIST PRODUCTION OF TELLURIUM, 1982-84**

| | 1982 | 1983 | 1984e |
|---|---|---|---|
| | (tonnes) | | |
| Japan | 63 | 65 | 65 |
| Peru | 21 | 22 | 22 |
| Canada | 9 | 23 | 15 |
| India | 0.2 | 0.2 | 0.2 |

Sources: U.S. Bureau of Mines, Energy, Mines and Resources Canada.

[1] Available data. United States withholds its figures to avoid disclosing company data, but accounted for 42 per cent of world output in 1975.
e Estimated.

# Silica

MICHEL A. BOUCHER

## SUMMARY

With the exception of sandblasting, flat glass and to some extent fiberglass, most other markets for silica remained weak in 1983 and in 1984 including foundry sand, container glass, artificial abrasives and smelter flux.

This was due to the low level of economic activity in North America in general, and problems in the automotive, steel and base-metal industries.

Imports of cars and automotive engines, a greater use of aluminum diecastings, and the downsizing of cars continued to depress markets for foundry sand, resulting in additional closures of foundries during the past two years. The glass container industry continued to be affected negatively by recycling and by strong competition from plastics and aluminum. New designs for beer bottles, however, helped producers temporarily in late 1983 and early 1984.

A silicon carbide operation was permanently closed due to poor demand for abrasives by the foundry and steel industries.

Demand for smelter flux was also weak as most base-metal smelters continued to operate at low levels of capacity.

Deregulation of transportation through the Staggers Act in the United States lowered freight rates and resulted in stronger competition from U.S. material exported to Canada.

Prices per t of silica shipped from Canadian producers decreased from an average of $18.71 in 1982 to $16.70 in 1983 and $15.95 in 1984 although shipments increased substantially from their very depressed level of 1982.

## CANADIAN SCENE

### Newfoundland

All silica production from Dunville Mining Company Limited, a subsidiary of ERCO Industries Limited is captive to ERCO, a producer of elemental phosphorous, where silica is used as a flux.

The quartzite quarry at Villa Marie operates from May to December, and production at Dunville increased substantially in recent years due to an expansion at ERCO.

### Nova Scotia

Nova Scotia Sand and Gravel Limited produces a high purity silica from sand deposits, for a variety of uses including sandblasting, glass, foundry sand, frac sand etc.

However, due to the closure of The Enterprise Foundry Company Limited in New Brunswick and Fiberglas Canada Inc. also in New Brunswick sales were substantially reduced in 1983 and 1984.

### New Brunswick

Chaleur Silica Ltd. produces silica for use as a flux by Brunswick Mining and Smelting Corporation Limited's Belledune lead smelter, for cement plants, and as sandblasting material.

Water cleaning equipment was added to the plant in 1984 and the company also invested $150,000 to increase storage capacity.

### Quebec

Indusmin Limited is the largest producer of silica east of Ontario with a reported

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production capacity of some 500 000 tpy. Silica is mined from a quartzite deposit at Saint Donat and from a sandstone deposit at Saint Canut. Silica from Saint Donat is refined at the Saint Canut plant near Montreal.

Most silica produced by Indusmin originates from Saint Canut where the ore is crushed, screened and beneficiated by attrition scrubbing, flotation and magnetic separation. Sales in 1983 and 1984 were reported to be higher than the depressed levels reached in 1982 as more silica was shipped outside of Quebec where Indusmin expanded its market share at the expense of smaller producers.

Baskatong Quartz Inc. continued to operate a high-purity silica deposit from a quartzite deposit north of Saint Urbain. The silica is used mainly by SKW Canada Inc. for the production of ferrosilicon and silicon metal. The small, but very high purity silica operation of Saint Ludger was temporarily closed in 1983. Baskatong continued exploring for new prospects in Quebec and the Maritimes, and in 1984 the company started producing very high purity silica for the photo-voltaic industry.

Melocheville Mining Limited did not produce silica from its Potsdam sandstone deposit of Beauharnois in 1983, but production resumed in 1984. The lump ore is used by Timminco Limited for Fe-Si and Si-Mn production, while the fines portion is sold to cement companies.

The Union Carbide Canada Limited's quartzite sandstone quarry at Beauharnois was not operational in 1983 nor in 1984. The company used the ore that had been mined in previous years for its Si-Mn and Fe-Mn alloy plant at Beauharnois.

Armand Sicotte & Sons Limited mined Potsdam sandstone at Saint Clothilde, south of Montreal. Lump silica is used for ferrosilicon and phosphorus production.

Sable de Silice Crémasie Inc. continued to mine silica sand and gravel from St. Joseph-du-Lac and from Ormstown. The material is used mainly for sandblasting but also for fiberglass, glass and foundries. The company plans to develop a sandstone deposit at Howick where silica would be used by the glass and fiberglass industries. In 1984, Bon Sable purchased a high magnetic separator to lower the iron content of the Howick ore.

**Ontario**

Indusmin Limited is the largest producer of silica west of Quebec, with a reported capacity of about 500 000 tpy, about the same as its Quebec operation. Lump quartzite from Badgeley Island, north of Georgian Bay is shipped by lake boat to Canadian destinations for the manufacture of Fe-Si. The finer material produced by crushing, is shipped to Midland, south of Georgian Bay where it is further processed to a glass-grade silica sand, and silica flour for the ceramic and other uses.

Sales improved from the very depressed level of 1982 as the glass insulation and sheet glass sectors recovered appreciably. Also, more lumps were shipped to the Fe-Si producers. During 1983, exploration was concentrated on drilling of a new quartzite orebody near Badgeley Island.

**Manitoba**

Steel Brothers Canada Ltd. continued to operate a high-purity silica sand on Black Island in Lake Winnipeg some 130 km north of Selkirk. The silica is mined from a poorly consolidated white sandstone. The sand is well rounded and suitable for foundry, glass and fiberglass manufacturers. The ore is washed, screened and dewatered at the plant on the island, and is then shipped by barge to a finishing plant at Selkirk on the Red River.

Due to poor sales in farming equipment in recent years some foundries were closed and sales were lost. The company, however, reported increased sales in the glass container industry.

Inco Limited continued to produce a low-grade silica from an impure quartzite from the Manasan quarry for its Thompson smelter.

Production varies from year to year depending on nickel production and silica is used as flux in Inco's converter.

**Alberta**

Sil Silica a division of Strathcona Resource Industries Ltd. produces silica sand from local sand dunes in the Bruderheim area. Silica is sold mainly as fiberglass and sandblasting material. It is also sold as foundry sand, filtration sand, frac sand and as railway traction sand.

In 1983 the company invested $1 million in a plant to produce silica flour for use as an addition to cement when completing oil wells that require high-temperature steam injection to liberate the oil.

**British Columbia**

The Mountain Minerals Co. Ltd.'s operation which mines a high-purity sandstone deposit near Golden reported that it was upgrading its processing plant. Silica is sold mainly for the glass and sandblasting industries but sections of the sandstone deposit where silica sand is loosely consolidated may eventually be mined and sold as foundry material. The company is also trying to develop a higher purity silica for high-tech applications.

## TRADE

Most silica sand imported into Canada comes from poorly consolidated sandstone or lake sand deposits located near the Great Lakes region of the United States.

The silica sand is used mainly by iron and steel foundries and by the glass industry of Ontario and Quebec.

In recent years, total Canadian imports of silica sand for use in foundries and glass industry were respectively about 400 000 t and 325 000 t. However, these imports have declined steadily since 1979, reflecting lower demand.

The industry claims that recent deregulation of rail freight rates in the United States resulting from the Staggers Act has increased the competitiveness of U.S. companies that ship silica to Canada.

## OUTLOOK

Not much improvement is expected in 1985 in Canada's three major markets for silica namely the glass, foundry and fiberglass industries.

In the medium term, competition from U.S. producers of silica for glass and foundry sand will remain strong in Ontario and Quebec because of the proximity of these provinces to the low cost producers of the U.S. Great Lakes region.

Also due to the downsizing of cars, recycling of silica sand at foundries, and other factors, as mentioned before, no growth is expected in the foundry sand industry in Canada.

Competition from substitutes for glass containers such as plastics and aluminum will remain strong across Canada.

Growth in fiberglass production will be restricted by a slow growth expected in construction activity in Canada, and by more dense materials that can be used as substitutes.

In the long-term, there is potential in Canada for the development of a deposit on Iles-de-la-Madeleine in the Gulf of St. Lawrence where silica sand and byproduct feldspar could be sold to foundries, glass and ceramic producers of northeastern United States.

There is also potential for the establishment of a flat glass producing facility in western Canada, where no such plants exist; good quality silica would be readily available as well as cheap natural gas or electricity.

Eventually higher quality silica products could be manufactured in Canada including optical quartz, cultured quartz (based on cheap electricity), solar grade silica, optical fibres and fumed "pyrogenic" silica (produced chemically or through the plasma route).

## PRICES

The following tables give the average price of different silica products in 1983.

| Silica | U.S./t f.o.b. mine or plant |
|---|---|
| Metallurgical | 7 |
| Glass | 9-14 |
| Foundry | 10-20 |
| Frac sand | 24 |
| Fiberglass | 25 |
| Filler | 33 |
| Pyrogenic silica | 5000-9000 |
| Cultured quartz (as ground bars) | 55000-90000 |

Source: Personal communications with industry.

**TARIFFS**

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| CANADA | | | | | |
| 29500-1 | Ganister and sand | free | free | free | free |
| 29700-1 | Silex or crystallized quartz, ground or unground | free | free | free | free |
| UNITED STATES | | | | | |
| 513.14 | Sand, other | | free | | |
| 514.91 | Quartzite, whether or not manufactured | | free | | |
| 523.11 | Silica, not specially provided for | | free | | |

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | ¢ per long ton | | | | |
| 513.11 | Sand containing 95% or more silica, and not more than 0.6% of oxide of iron | 12 | 9 | 6 | 3 | free |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1983), USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, SILICA PRODUCTION (SHIPMENTS) AND TRADE, 1982-84

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($'000) | (tonnes) | ($'000) | (tonnes) | ($'000) |
| **Production (shipments), quartz and silica sand** | | | | | | |
| By province | | | | | | |
| Quebec | 661 000 | x | 709 300 | x | 758 000 | x |
| Ontario | 438 000 | 8,227 | 874 548 | 11,466 | 1 122 404 | 11,481 |
| Alberta | x | x | x | x | x | x |
| Manitoba | x | x | x | x | x | x |
| Nova Scotia | x | x | x | x | x | x |
| New Brunswick | x | x | x | x | x | x |
| Saskatchewan | 99 000 | 1,066 | 123 062 | 1,476 | 120 741 | 1,510 |
| Newfoundland | x | x | x | x | x | x |
| British Columbia | x | x | x | x | x | x |
| Total | 1 703 000 | 31,864 | 2 303 451 | 38,467 | 2 624 002 | 41,863 |
| By use | | | | | | |
| Glass and fiberglass | 430 000 | 11,906 | .. | .. | | |
| Flux | 391 000 | 2,114 | .. | .. | | |
| Ferrosilicon | 155 000 | 925 | .. | .. | | |
| Other uses[1] | 727 000 | 16,919 | .. | .. | | |
| Total | 1 703 000 | 31,864 | 2 303 451 | 38,467 | 2 624 002 | 41,863 |
| **Imports** | | | | | | |
| Silica sand | | | | | (Jan.-Sept. 1984) | |
| United States | 788 468 | 15,475 | 982 568 | 16,864 | 767 577 | 13,892 |
| West Germany | - | - | 56 | 17 | 5 | 1 |
| Other countries | 300 | 120 | 38 | 2 | - | - |
| Total | 788 768 | 15,595 | 982 662 | 16,883 | 767 582 | 13,893 |
| Silex and crystallized quartz | | | | | | |
| United States | 230 | 265 | 245 | 237 | 342 | 268 |
| Japan | 1 | 1 | 20 | 15 | 9 | 8 |
| Other countries | 10 | 16 | 3 | 3 | 1 | 1 |
| Total | 241 | 282 | 271 | 255 | 352 | 277 |
| Firebrick and similar shapes, silica | | | | | | |
| United States | 2 584 | 2,021 | 1 981 | 2,983 | 2 530 | 2,216 |
| France | 219 | 254 | 649 | 454 | 431 | 508 |
| West Germany | 52 | 49 | 360 | 84 | 48 | 48 |
| Other countries | 129 | 82 | 37 | 40 | - | - |
| Total | 2 984 | 2,406 | 3 027 | 2,671 | 3 017 | 2,772 |
| **Exports** | | | | | | |
| Quartzite | | | | | | |
| United States | 65 314 | 566 | 103 944 | 936 | 73 547 | 656 |
| Other countries | 19 | 2 | 16 | 2 | 18 | 1 |
| Total | 65 333 | 568 | 103 960 | 938 | 73 565 | 675 |

Source: Statistics Canada; Energy, Mines and Resources Canada.

[1] Includes foundry use, sand blasting, silica brick, concrete products, chemical manufacture, building products and silicon carbide.

P Preliminary; - Nil; x Confidential.

## TABLE 2. IMPORTS BY PROVINCE OF SILICA SAND AND SILEX AND CRYSTALLIZED QUARTZ, 1982 AND 1983

| | 1982 | | 1983 | |
|---|---|---|---|---|
| | (tonnes) | ($) | (tonnes) | ($) |
| Silica sand | | | | |
| Ontario | 583 149 | 9,202,483 | 709 149 | 8,555,711 |
| British Columbia | 80 226 | 2,904,414 | 144 282 | 4,769,588 |
| Saskatchewan | 16 794 | 601,072 | 32 638 | 1,140,835 |
| Alberta | 44 866 | 1,638,964 | 31 132 | 1,134,443 |
| Quebec | 61 338 | 1,142,205 | 57 279 | 988,455 |
| Manitoba | 1 107 | 84,305 | 6 926 | 270,595 |
| Nova Scotia | 435 | 8,248 | 658 | 15,527 |
| New Brunswick | 810 | 12,075 | 553 | 7,403 |
| Newfoundland | - | - | 45 | 602 |
| Prince Edward Island | 43 | 1,010 | - | - |
| Total | 788 768 | 15,594,776 | 982 662 | 16,883,159 |
| Silex and crystallized quartz | | | | |
| Ontario | 146 | 167,305 | 185 | 156,394 |
| British Columbia | 11 | 17,551 | 34 | 49,466 |
| Quebec | 6 | 6,124 | 48 | 46,242 |
| Alberta | 77 | 90,567 | 4 | 3,181 |
| Saskatchewan | 1 | 665 | - | - |
| Manitoba | .. | 107 | - | - |
| Total | 241 | 282,319 | 271 | 255,283 |

Source: Statistics Canada.
.. Not available; - Nil.

## TABLE 3. CANADA, SILICA PRODUCTION AND TRADE, 1970, 1975, 1979-84

| | Production | Imports | | | Exports | Consumption |
|---|---|---|---|---|---|---|
| Year | Quartz and Silica Sand | Silica Sand | Silex or Crystallized Quartz | Firebrick and Similar Shapes | Quartzite | Quartz and Silica Sand |
| | | | (tonnes) | | | |
| 1970 | 2 937 498 | 1 176 199 | 186 | 2 020 | 58 917 | 3 979 305 |
| 1975 | 2 491 715 | 1 044 160 | 1 550 | 18 818 | 39 977 | 3 510 818 |
| 1979 | 2 368 497 | 1 651 890 | 1 259 | 4 896 | 60 823 | 3 611 815 |
| 1980 | 2 252 000 | 1 200 237 | 281 | 4 775 | 63 166 | 3 326 956r |
| 1981 | 2 238 000 | 1 142 880 | 251 | 13 762 | 119 347 | 3 079 225r |
| 1982 | 1 797 000r | 788 768 | 241 | 2 984 | 65 333 | 2 623 263r |
| 1983 | 2 303 451 | 982 662 | 271 | 3 027 | 103 960 | .. |
| 1984P | 2 624 002 | | | | | |

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; .. Not available; r Revised.

TABLE 4. CANADA, ESTIMATED CONSUMPTION OF SILICA, BY INDUSTRIES, 1981-82

| | 1981 | 1982 |
|---|---|---|
| | (tonnes) | |
| Glass manufacture (including glass fibre) | 951 442 | 1 120 565 |
| Smelter flux[1] | 724 040[r] | 387 482 |
| Foundry sand[1] | 467 954[r] | 336 119 |
| Refractory brick mixes, cements | 359 225[r] | 262 541 |
| Metallurgical | 143 447 | 164 987 |
| Concrete products | 211 608 | 149 539 |
| Artificial abrasives | 125 706 | 112 785 |
| Chemicals | 39 430 | 36 877 |
| Fertilizer, stock poultry feed | 4 038[r] | 3 398 |
| Gypsum products | 2 314 | 2 878 |
| Other[2] | 50 021[r] | 46 092 |
| Total | 3 079 225[r] | 2 623 263 |

[1] Reallocation of data, commencing in 1981, attributable to revision in survey coverage.
[2] Includes asbestos products, ceramic products, frits and enamels, paper and paper products, roofing and other minor uses.
[r] Revised.

# Silicon, Ferrosilicon, Silicon Carbide and Fused Alumina

D. PHILLIPS

## SUMMARY

The consumption of ferrosilicon is directly related to the consumption of steel and ferrous castings. Canadian ferroalloy companies have remained competitive due to their domestic source of raw material, low energy costs and modern plants. The investment by Elkem A/S in the Canadian ferrosilicon industry, through its aquisition of Union Carbide Canada Ltd. could strengthen the latter organization's international marketing capability and makes accessible the specialized ferroalloy technology necessary to remain competitive.

Silicon is the second most abundant element in the earth's crust and world resources of this metal are almost inexhaustible. Silica deposits ($SiO_2$) are the main commercial source of silicon. The production of silicon metal, ferrosilicon and silicon carbide from silica ores requires large amounts of electricity and, therefore, production plants are usually situated in areas with an abundant supply of electrical power. In Canada, these silicon products are manufactured in plants in Quebec and southern Ontario.

## CANADIAN DEVELOPMENTS

The Canadian ferrosilicon and silicon metal industry is concentrated in Quebec where large supplies of hydroelectric power and raw materials are available. There were three producers of primary ferrosilicon in 1983 and 1984, two of which produced silicon metal. Byproduct ferrosilicon was also produced in the manufacture of fused aluminum oxide abrasives.

Ferrosilicon is offered for sale in several grades, expressed in terms of per cent contained silicon. The more common grades of 50, 75 and 85 per cent are produced for consumption by the steel industry. Byproduct ferrosilicon usually grades below 20 per cent; the most common use for this material is in the flotation circuit of mineral processing operations.

The Canadian ferrosilicon industry operated at approximately 80 per cent of capacity in 1983 and near capacity in 1984, with the exception of the Elkem Metal Canada Inc. Beauharnois, Quebec facility, which closed in May of 1982 and was not reopened by year-end 1984.

SKW Canada Inc.'s production in 1983 and 1984 was estimated to be 25 000 tonnes (t) of 75 per cent grade ferrosilicon and 25 000 t of silicon metal in each of these years. SKW exports most of its production, mainly to the United States, Japan and West Germany.

Elkem Metal Canada Inc. (previously Union Carbide Canada Ltd.), which closed its ferrosilicon and silicon metal facility at Beauharnois in 1982, did not reopened it in 1983 and 1984. Elkem continued to operate its ferrosilicon plant at Chicoutimi, Quebec where an estimated 25 000 t of 75 per cent grade ferrosilicon was produced each year in 1983 and 1984.

Following the 1981 acquisition of the U.S. ferroalloy facilities of Union Carbide Corp. by Elkem A/S, the company exercised its legal option and acquired the assets of Union Carbide Canada Ltd. in 1984. Elkem planned to have its Canadian marketing office based in Toronto. The owners also negotiated a new power contract with Hydro-Québec. This acquisition by Elkem A/S should strengthen the formerly held Union Carbide organization because of Elkem's world-wide operations.

Timminco Canada Limited's (previously Chromasco Limited) total 1984 production of ferrosilicon was estimated at 40 000 t. About one-half of this was in the form of 50 per cent grade and the rest was divided between the 75 and 85 per cent grades. The 1983 production was approximately 20 per cent less than that of 1984.

The abundance of relatively inexpensive electrical energy also enables Canada to produce and export bulk quantities of synthetic

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abrasives, such as silicon carbide (SiC) and fused alumina ($Al_2O_3$). Producers of these abrasives are located in Quebec and Ontario. The Quebec-based companies, with products shown in brackets, are: Carborundum Canada Inc., Shawinigan (SiC); Norton Company (SiC) and Electro Refractories & Abrasives Canada Ltd., both in Cap-de-la Madeleine (SiC); and Unicorn Abrasives of Canada Limited, Arvida ($Al_2O_3$). The Ontario-based companies are: Carborundum Canada Inc. ($Al_2O_3$), Norton Company ($Al_2O_3$ and SiC) and Usigena (Canada) Limited ($Al_2O_3$ and SiC), all of Niagara Falls; and The Exolon Company of Canada, Ltd., Thorold ($Al_2O_3$ and SiC). All Canadian production of synthetic abrasives is exported, principally to the United States where the bulk material is crushed, screened and classified. A small part of the processed material is reimported for the production of bonded abrasives such as abrasive wheels and coated abrasives such as sandpaper.

## INTERNATIONAL DEVELOPMENTS

Due to a rising consumption of steel in the Lesser Developed Countries (LDC's), there has been a corresponding increase in demand for ferrosilicon. In order to meet this increased demand, some of the LDC's have increased their ferrosilicon capacities, namely: Brazil, Yugoslavia, the Philippines, Egypt and Venezula.

In response to predicted shortages of world ferrosilicon production, capacity was increased by an estimated 98 000 t contained silicon in the late 1970s and early 1980s. World utilization of production capacity was estimated at 65 per cent in 1983 and is predicted to be 80 to 85 per cent by 1990, equivalent to 3.7 million t.

Companies in both Norway and the United States have been upgrading their ferrosilicon manufacturing facilities. Canada's ferrosilicon industry, which is relatively new, should remain competitive, especially when its abundance of raw materials and low energy costs are taken into consideration.

In 1984 Elkem A/S transacted the sale of some of its shares in Icelandic Alloys to Sumitomo. The government of Iceland has a controlling interest in the company and Sumitomo has acquired a 15 per cent share interest. It is estimated that Icelandic Alloys will increase its annual shipments of ferrosilicon, to Japan from 8 000 t to 20 000 t. Canada's annual production of ferrosilicon, which is estimated at 100 000 t, remains at approximately one-fifth that of the U.S.S.R. production and approximately one-quarter those of Norway and the United States.

## USES

Silicon metal is used mainly as an alloying agent for aluminum. It increases fluidity and corrosion resistance, as well as thermal and electrical conductivity. In addition, silicon metal reduces the specific density and thermal expansion of aluminum alloys. These alloys are used principally to make aluminum castings, and contain on average about 6 per cent silicon. More than one-half of the cast aluminum tonnage is used in the transportation industry. Another important use of silicon metal is in the fabrication of silicones, which are used in oil production and for the manufacture of more than 200 products, including synthetic rubber resins and electric motor insulation. Silicon metal is also used to make silicon bronze, aluminum alloys for coating steel sheets, semiconductor electronic devices and silicon nitride ($Si_3N_4$).

The iron and steel industry is the largest user of ferrosilicon and other silicon alloys such as silicocalcium, silicochrome and silicomanganese. Ferrosilicon functions primarily as a deoxidizer in molten steel. In addition, it is used as a graphite promoter during the production of carbon steels, as an additive to improve the electrical properties of electric steels and as a reducing agent in the manufacture of nonferrous alloys. Carbon steel contains on average 0.755 kg of silicon per t of steel, and consumes about one-third of Canadian ferrosilicon production. Stainless steels and electric steels, which contain an average of 10 and 20 kg of silicon respectively per t of steel, and other types of steel consume the remaining two-thirds. Ferrosilicon is also used in the silicothermic process for the production of other metals, but only small tonnages are required for this purpose.

## OUTLOOK

The outlook for Canadian ferrosilicon and silicon metal production during 1985 is not expected to change from 1984. Three of the four ferrosilicon plants are expected to remain at capacity rates of production except for normal maintenance outages.

Potential areas for expanding silicon metal consumption include the electronics industry where high purity silicon metal is used to produce silicones; the alloy industry, where silicon has scope to substitute for other metals; and the solar energy field, where silicon alloys are widely used in heat exchanger systems.

The future demand for ferrosilicon, which is directly related to the steel and ferrous casting industry (80 per cent of total consumption), is forecast to show moderate increases in growth to the year 1990 of approximately 2.6 per cent per annum. Western world capacity, which presently stands at approximately 1.4 million t, is expected to decrease by approximately 1 per cent. Accordingly, capacity utilization is forecasted to increase approximately 10 per cent by 1990.

**PRICES**

| As published by **METALS WEEK** in December 1982, 1983 and 1984 | | 1982 | 1983 | 1984 |
|---|---|---|---|---|
| | | | (¢US) | |
| Ferrosilicon, U.S. producer, per pound of silicon content; lump bulk lots, fob shipping point | | | | |
| High-purity 75% Si | | 47.00 | 43.00 | 47.00 |
| Regular 50% Si | | 45.00 | 43.00 | 45.00 |
| Silicon metal, per pound contained silicon, fob shipping point, lump, bulk and carload lots, | | | | |
| (% max. Fe) | (% max. Ca) | | | |
| 0.35 | 0.07 | 66.80 | 65.35 | 68.85 |
| 0.50 | 0.07 | 64.50 | 63.05 | 66.55 |
| 1.00 | 0.07 | 62.00 | 60.25 | 63.75 |

| Prices published by **AMERICAN METAL MARKET** in December 1982, 1983 and 1984 | 1982 | 1983 | 1984 |
|---|---|---|---|
| | | (¢US) | |
| SMZ alloy: 60-65% Si, 5-7% Mn, 5-6% Zr, ½ in. x 12 M, per pound of alloy | 53.25 | 55.90 | .. |
| Calcium-silicon and calsibar alloy, fob producer, 15-ton lots, per pound | 66.00 | 72.00 | 72.00 |
| Electric furnace silvery pig iron, fob Keobuck, Iowa | | | |
| 16% Si, per ton | 220.00 | 220.00 | 220.00 |
| 20% Si, per ton | 249.00 | 249.00 | 249.00 |

| Prices published by **INDUSTRIAL MINERALS** in December 1982, 1983 and 1984 (tonnes, cif main European port) | 1982 | 1983 | 1984 |
|---|---|---|---|
| | | (£) | |
| Fused alumina, 8-220 mesh, cif | | | |
| Brown, min. 94% $Al_2O_3$ | 350-420 | 350-420 | 350-420 |
| White, min. 99.5% $Al_2O_3$ | 410-500 | 410-500 | 410-500 |
| Silicon carbide, 8-220 mesh, cif | | | |
| Black, about 99% SiC - Grade 1 | 650-700 | 700-750 | 700-750 |
| - Grade 2 | 580-680 | 600-700 | 600-700 |
| Green, over 99.5% SiC | 850-850 | 850-950 | 850-950 |

fob Free on board; cif Cost, insurance and freight; .. Not available.

**TARIFFS**

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (cents) | | |
| CANADA | | | | | |
| 37502-1 | Silicomanganese - silico spiegel and other alloys of manganese and iron containing more than 1%, by weight, of silicon per pound or fraction thereof, on the manganese contained therein | free | 0.73 | 1.75 | free |
| 37503-1 | Ferrosilicon, being an alloy of iron and silicon containing 8% or more, by weight of silicon and less than 60%, per pound or fraction thereof, on the silicon contained therein | free | free | 1.75 | free |
| 37504-1 | Ferrosilicon, being an alloy of iron and silicon containing 60% or more, by weight, of silicon and less than 90%, per pound or fraction thereof, on the silicon contained therein | free | 0.73 | 2.75 | free |
| 37505-1 | Ferrosilicon, being an alloy of iron and silicon containing 90% or more, by weight, of silicon per pound or fraction thereof, on the silicon contained therein | free | 2.3 | 5.5 | free |
| 92804-1 | Silicon metal | 10% | 12.1% | 25% | 8% |
| 92815-4 | Silicon sulphide | 10% | 12.1% | 25% | 8% |

MFN Reductions under GATT
(effective January 1 of year given)

| | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (cents) | | |
| 37502-1 | 0.73 | 0.73 | 0.72 | 0.71 | 0.7 |
| 37504-1 | 0.73 | 0.73 | 0.72 | 0.71 | 0.7 |
| 37505-1 | 2.3 | 2.3 | 2.2 | 2.1 | 2.0 |
| | | | (%) | | |
| 92804-1 | 12.1 | 11.4 | 10.7 | 9.9 | 9.2 |
| 92815-4 | 12.1 | 11.4 | 10.7 | 9.9 | 9.2 |

UNITED STATES (MFN)

| | | |
|---|---|---|
| 519.21 | Crude silicon carbide | free |
| 519.37 | Silicon carbide in grains, ground, pulverized or refined | 0.3¢/lb |
| 606.35 | Ferrosilicon, containing 8-60% silicon | free |
| 606.42 | Ferrosilicon chromium | 10% |

**TARIFFS** (cont'd)

| UNITED STATES (cont'd) | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | (% unless otherwise specified) | | | | |
| 606.36 | Ferrosilicon, containing 60-80% silicon and over 3% calcium | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |
| 606.37 | Other ferrosilicon containing 60-80% silicon | 1.6 | 1.6 | 1.6 | 1.5 | 1.5 |
| 606.39 | Ferrosilicon containing 80-90% silicon | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 |
| 606.40 | Ferrosilicon containing over 90% silicon | 8.6 | 7.9 | 7.2 | 6.5 | 5.8 |
| 606.44 | Ferrosilicon manganese | 5.0 | 4.7 | 4.4 | 4.2 | 3.9 |

| EUROPEAN ECONOMIC COMMUNITY (MFN) | | 1983 | Base Rate | Concession Rate |
|---|---|---|---|---|
| | | | (%) | |
| 28.13 | Silicon dioxide | 5.5 | 6.4 | 4.6 |
| 73.02 | Ferrosilicon | 8.7 | 10.0 | 6.2 |
| | Ferrosilico-manganese | 5.5 | 5.5 | 5.5 |
| | Ferrosilico-chrome | 6.3 | 7.0 | 4.9 |
| JAPAN (MFN) | | | | |
| 28.04 | Silicon - single crystal | 9.0 | 15.0 | 7.2 |
| | - other | 5.3 | 7.5 | 4.9 |
| 28.56 | Silicon carbide | 5.3 | 7.5 | 4.9 |
| 68.06 | Abrasive paper | 8.6 | 15.0 | 6.5 |
| 73.02 | Ferrosilicon | 3.8 | 5.0 | 3.7 |

Sources: The Customs Tariff 1983, Revenue Canada Customs and Excise; Tariff Schedules of the United States Annotated (1983), USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241; Customs Tariff Schedules of Japan, 1983; Official Journal of the European Communities, Vol. 25, No. L318, 1982.

TABLE 1. CANADA, FERROSILICON, SILICON CARBIDE AND OTHER FERROALLOYS[1], EXPORTS AND IMPORTS, 1982-84

| | 1982 | | 1983P | | 1984 (Jan-Sept) | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Exports** | | | | | | |
| Ferrosilicon | | | | | | |
| United States | 14 457 | 10,473 | 27 120 | 17,371 | 26 050 | 20,219 |
| Japan | 22 340 | 15,268 | 14 909 | 11,536 | 14 647 | 13,571 |
| South Korea | 2 543 | 2,321 | 1 540 | 1,547 | 257 | 259 |
| West Germany | 434 | 551 | 1 560 | 1,491 | - | - |
| United Kingdom | 601 | 173 | 525 | 351 | 617 | 450 |
| Other countries | 452 | 423 | 61 | 85 | 216 | 200 |
| Total | 40 827 | 29,209 | 45 715 | 32,381 | 41 799 | 34,699 |
| Silicon carbide, crude and grains | | | | | | |
| United States | 57 847 | 30,847 | 64 707 | 40,457 | 52 213 | 32,144 |
| Other countries | 36 | 45 | - | - | - | - |
| Total | 57 883 | 30,892 | 64 707 | 40,457 | 52 213 | 32,144 |
| Ferroalloys, nes | | | | | | |
| United States | 2 603 | 4,050 | 2 266 | 4,520 | 2 294 | 5,941 |
| United Kingdom | | | | | 1 805 | 173 |
| Netherlands | - | - | 73 | 486 | - | - |
| Mexico | 52 | 86 | 179 | 438 | - | - |
| South Korea | 21 | 286 | 373 | 201 | - | - |
| Other countries | 2 381 | 703 | 1 291 | 379 | 62 | 69 |
| Total | 5 057 | 5,125 | 4 182 | 6,024 | 4 161 | 6,183 |
| **Imports** | | | | | | |
| Ferrosilicon | | | | | | |
| United States | 9 390 | 10,462 | 12 625 | 12,209 | 20 671 | 15,753 |
| South Africa | - | - | - | - | 6 077 | 2,636 |
| West Germany | 34 | 36 | 171 | 190 | - | - |
| France | 175 | 244 | 36 | 40 | 198 | 241 |
| Norway | 38 | 41 | 19 | 22 | 44 | 53 |
| Other countries | 9 | 9 | - | - | - | - |
| Total | 9 860 | 11,029 | 13 079 | 12,729 | | 15,683 |
| Silicomanganese, including silico spiegel | | | | | | |
| United States | 380 | 372 | 453 | 329 | 4 | 251 |
| Brazil | - | - | 7 | 3 | 2 | 2 |
| Other countries | 2 497 | 1,348 | - | - | - | - |
| Total | 2 877 | 1,720 | 460 | 332 | | |
| Ferroalloys, nes | | | | | | |
| United States | 2 926 | 5,033 | 4 094 | 8,624 | 4 933 | 9,794 |
| Brazil | 433 | 3,814 | 873 | 4,824 | 1 021 | 6,346 |
| France | 1 082 | 2,132 | 1 172 | 2,076 | 754 | 1,534 |
| Dominican Republic | 15 | 83 | 600 | 1,605 | 1 232 | 2,688 |
| United Kingdom | 112 | 160 | 83 | 300 | 196 | 819 |
| West Germany | 93 | 115 | 87 | 148 | 16 | 18 |
| Other countries | 146 | 821 | 136 | 322 | 307 | 444 |
| Total | 4 806 | 12,158 | 7 045 | 17,899 | 8 459 | 21,643 |

Source: Statistics Canada.
[1] Other important ferroalloys are discussed in the nickel and titanium reviews for 1983-84.
P Preliminary; - Nil; nes Not elsewhere specified.

## TABLE 2. CANADA, CONSUMPTION, EXPORTS, IMPORTS AND PRODUCTION OF FERROSILICON, 1970, 1975, 1979-84

| | Consumption[1] | Exports | | Imports | | Production[2] |
|---|---|---|---|---|---|---|
| | (tonnes) | (tonnes) | ($ 000) | (tonnes) | ($ 000) | (tonnes) |
| 1970 | 50 556 | 45 345 | 8,284 | 9 477 | 2.386 | 86 424 |
| 1975 | 54 904 | 29 029 | 8,075 | 26 353 | 15,665 | 57 580 |
| 1979 | 61 928 | 40 732 | 21,962 | 19 855 | 14,041 | 82 805 |
| 1980 | 63 321 | 52 164 | 33,866 | 18 508 | 13,869 | 96 977 |
| 1981 | 62 090 | 52 410 | 36,722 | 18 629 | 15,605 | 95 871 |
| 1982 | 46 122 | 40 827 | 29,209 | 9 860 | 11,029 | 77 089 |
| 1983 | 50 022 | 45 715 | 32,381 | 13 079 | 12,729 | 95 737 |
| 1984 | 60 000P | .. | .. | .. | .. | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Consumption as reported by consumers. [2] Consumption plus net exports equals derived production.
P Preliminary; .. not available.

## TABLE 3. CANADA, MANUFACTURERS' SHIPMENTS OF CRUDE SILICON CARBIDE 1970, 1975, 1978-82

| | (tonnes) | ($ 000) |
|---|---|---|
| 1970 | 104 113 | 17,653 |
| 1975 | 89 346 | 24,597 |
| 1978 | 106 763 | 38,763 |
| 1979 | 101 265 | 44,108 |
| 1980 | 86 353 | 46,897 |
| 1981 | 89 977 | 50,758 |
| 1982 | 71 518 | 42,913 |

Source: Statistics Canada.

## TABLE 4. CANADA, EXPORTS OF SILICON CARBIDE, CRUDE AND GRAINS 1970, 1975, 1979-83

| | (tonnes) | ($ 000) |
|---|---|---|
| 1970 | 96 159 | 15,976 |
| 1975 | 78 615 | 17,441 |
| 1979 | 84 436 | 31,258 |
| 1980 | 72 414 | 33,244 |
| 1981 | 67 144 | 34,595 |
| 1982 | 57 884 | 30,892 |
| 1983P | 64 707 | 40,457 |

Source: Statistics Canada.
P Preliminary.

## TABLE 5. CANADA, MANUFACTURERS' SHIPMENTS OF CRUDE FUSED ALUMINA 1970, 1975, 1978-82

| | (tonnes) | ($ 000) |
|---|---|---|
| 1970 | 131 364 | 18,088 |
| 1975 | 110 736 | 26,162 |
| 1978 | 154 303 | 49,916 |
| 1979 | 152 118 | 51,206 |
| 1980 | 146 655 | 56,957 |
| 1981 | 149 840 | 57,949 |
| 1982 | 114 479 | 53,816 |

Source: Statistics Canada.

## TABLE 6. CANADA, EXPORTS OF FUSED ALUMINA, CRUDE AND GRAINS, 1970, 1975, 1979-83

| | (tonnes) | ($ 000) |
|---|---|---|
| 1970 | 152 572 | 23,234 |
| 1975 | 127 658 | 26,650 |
| 1979 | 183 124 | 55,138 |
| 1980 | 166 328 | 55,867 |
| 1981 | 157 990 | 67,954 |
| 1982 | 114 551 | 55,492 |
| 1983P | 109 864 | 57,568 |

Source: Statistics Canada.
P Preliminary.

# Silver

D. LAW-WEST

In 1984, silver prices did not retain the gains made during 1983. Higher interest rates coupled with lower inflation reduced investor interest in precious metals and resulted in falling prices.

World mine output of silver was estimated at 12 700 t in 1984, somewhat higher than the 12 100 t in 1983. Canadian silver production remained unchanged from 1983 to 1984, however there was some geographical shifts in production.

## CANADIAN DEVELOPMENTS

Canadian primary production of silver in 1984 was estimated at 1 172 000 kg compared to 1 197 000 kg in 1983. A major increase in production occurred in Ontario while several other provinces recorded significant decreases.

Canadian Copper Refiners Limited at Montreal East, Quebec, was Canada's largest producer of refined silver, mainly from the treatment of copper anodes and blister copper and the further refining of lower-grade silver bullion. The silver refinery of Cominco Ltd. at Trail, British Columbia, was the second largest producer, recovering byproduct silver in the processing of its own ores, as well as custom lead, zinc and silver ores and concentrates. Other producers of refined silver were Inco Limited at Copper Cliff, Ontario (from nickel-copper concentrates), and the Royal Canadian Mint at Ottawa, Ontario (from gold bullion). At Cobalt, Ontario, Canadian Smelting & Refining (1974) Limited recovered silver from silver-cobalt ores and concentrates produced in that area. At Belledune, New Brunswick, the Smelting Division of Brunswick Mining and Smelting Corporation Limited recovered byproduct silver from lead concentrates treated in a blast furnace.

At its electronic materials plant at Trail, Cominco also produces a high-purity silver metal with metallic impurities totalling one part per million or less. This specialty metal product is manufactured mainly for applications such as solder preforms, brazing preforms and lead wire in the electronics industry.

Silver production in the Atlantic provinces came almost entirely as a byproduct from the base-metal producing operations of Brunswick Mining and Smelting Corporation Limited in New Brunswick.

The Buchans Mine of ASARCO Inc. in Newfoundland operated between July 1983 and August 1984 when final ore reclamation was completed. The mine has been permanently closed.

In Quebec, silver production is mainly a byproduct of base-metal mining and a minor amount as a byproduct of gold mining. Les Mines Selbaie a subsidiary of Selco Inc. remained the leading silver producer in the province.

In Ontario, Kidd Creek Mines Ltd. (KCML) continued as the province's largest silver producer. Despite weak markets for lead and copper, Kidd Creek operated in 1984 near its normal rate. Agnico Eagle Mines Ltd. increased its silver production in the Cobalt Ontario area by 38 per cent in 1983 and a further increase of 36 per cent was expected for 1984.

Silver production in Manitoba and Saskatchewan is as a byproduct of base-metal mines operated by Hudson Bay Mining and Smelting Co. Limited in the Flin Flon-Snow Lake area and by Sherritt Gordon Mines Limited from the Fox mine near Lynn Lake and the Ruttan Mine at Leaf Rapids. The Fox mine is expected to close in 1986 and at the Ruttan mine production is planned from the deeper parts of the orebody.

Equity Silver Mining Limited, a subsidiary of Placer Development Ltd. is by far the largest silver producer in British Columbia. The company expects to increase production by some 18 000 kg of silver by the end of 1984, when a precious metals scavanger circuit is fully operational in the mill.

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Cominco Ltd. continued to recover byproduct silver from the Sullivan lead-zinc mine, which operated normally during 1984. Other important silver producers in the province included Lornex Mining Corporation Ltd. and Westmin Resources Ltd.

Silver production in the Yukon was up from 18 000 kg to 43 900 kg in 1984 mainly as the result of the reopening of United Keno's operations near Elsa. The low silver prices of the last half of 1984 placed the continued operation of United Keno in question, however, the company's exploration program has uncovered some promising discoveries for further evaluation.

During the first nine months of 1984 exports of silver in ores, concentrates and as refined metal totalled 1 118 397 kg compared with 1 165 396 kg in the corresponding period in 1983. Canada's largest market for ores and concentrates was Japan, while the United States remained the largest market for Canadian refined silver.

Canadian imports of refined silver for the first nine months of 1984 amounted to 181 180 kg, mainly from the United States.

Consumption of silver for all uses in 1983 was estimated at about 200 000 kg up slightly from the 180 500 kg consumed during 1982.

## INTERNATIONAL DEVELOPMENTS

Estimated world production of silver in 1983 was 12 130 t, slightly above the 1982 figure (Table 5). The Silver Institute has estimated 1984 world mine production at 12 700 t.

Based on preliminary data, Canada dropped to fifth place in 1983 behind Mexico, Peru, U.S.S.R. and the United States. These five countries account for about 64 per cent of the world's total primary silver production.

World consumption of silver during 1983 for both industrial and coinage usage was estimated at 11 400 t by Handy & Harman, compared with 11 250 t in 1982. Most of the difference in consumption is accounted for by the U.S. Olympic coin program.

Peru has emerged as a major world producer. Peruvian production has been growing at an average annual rate of about 3.5 per cent, since 1968. Approximately 10 per cent of Peru's output originates in 28 mines with western Andes, base metal mines account for about 65 per cent with primary silver mine account for the remainder of production. Potential for further growth in silver production depends upon the successful completion of three projects currently under construction, which could add 87 000 kg annually.

During 1983, Mexico reestablished its self as the world's leading silver producer, at the same time setting a new production record. The previous record had been set in 1945. A large part of the production increase was the result of the first full year of production at the 10 000 tpd open-pit mine at the Real de Angeles joint venture. The partners are: Placer Development Ltd. (34 per cent), the Mexican Government (33 per cent), and Frisco SA de CV (33 per cent). Annual silver production from this project will be about 220 000 kg, making it the largest silver producer in Mexico.

Many of the smaller Mexican silver mines have expansions under way or are planning expansions. Mexican authorities have forecast silver production for 1984 at some 3 250 t.

In the United States, Sonora Gold Corp. began preproduction work at its Jamestown mine in California. When completed the operation will produce about 4 300 kg of silver per year.

Hecla Mining Corp. consolidated its position as the largest silver producer in the United States, through a complex trade involving Sunshine Mining Company and Rancher's Exploration and Development. Hecla now produces some 255 000 kg per annum. Sunshine, the country's second largest producer produces about 165 000 kg.

The disposal of silver from the U.S. National Defense Stockpile again became an issue in 1984. Legislation was signed early in U.S. fiscal year 1985 authorizing the disposal of 10 million oz of silver from the stockpile. The disposal however is contingent on an impact report being submitted to Congress. There is some doubt as to whether the approved silver disposal will go ahead.

In Chile, small and medium-scale silver mines will receive support from the government. Enami announced a price support program paid on a sliding scale of around $10 per oz for silver refined at the state owned refinery during the second half of

1984. The mine must repay Enami the difference between their realized sale price and future prices, once the market recovers.

## CONSUMPTION AND USES

Western-world silver consumption increased during 1984. This was mainly due to increased demand for the end products associated with silver use, namely photography, electronic equipment and sterlingware and jewelery.

Photography is the largest single use for silver accounting for about 40 per cent of industrial consumption. While silver use by this industry has been rising over the past three years, it remains nearly 10 per cent below consumption in the late 1970s. The high silver prices of 1979 and 1980 led the photographic industry to reduce the amount of silver per exposure while at the same time increasing the silver recovered from spent photographic materials. Colour and black and white photographs account for some 55 per cent of silver used in photography, x-ray photographs account for about 35 per cent, while the remaining 10 per cent is broadly utilized in graphic arts, engineering and other industrial uses. Each of these sectors face different conditions that affects the amount of silver consumed. The colour and black and white print business faces competition from silver-free technology such as electronic or video photo-imaging. However, at the same time the number of amateur photographers are increasing and demand for photographic materials is increasing in developing countries. According to some analysts this sector should experience growth on average.

Since the x-ray sector is mainly centred around hospitals there is fairly complete recycling of used x-ray films, depending upon the length of time which the x-rays are kept on record. The major threat to silver x-ray prints is from digital storage of x-rays using chromium-dioxide video tapes. In addition traditional x-ray machines are facing competition from other machines such as catscans and nuclear magnetic rosand units which could easily be linked with non silver video recording equipment in lieu of the traditional silver-based x-ray prints.

The electrical and electronic industry accounts for about 30 per cent of consumption. Silver's superior electrical conductivity accounts for its extensive use as contacts, conductors, resistors and capacitors in electronic components. Silver is most often required where a high degree of dependability is required. Spacecraft, satellites and aircraft guidance systems are typical examples. Also silver-zinc and silver-cadmium batteries are used in spacecraft and jet aircraft. Consumption in the electronics industry will increase with the increased popularity of home entertainment units such as video casette recorders and home micro computers, however, the move toward miniaturization will largely offset the increased numbers.

Sterlingware and jewellery combined account for about 5 per cent of consumption. Silver usage in these industries has declined substantially since the mid-1970s when in the United States sterlingware producers used 22-30 million ounces, while jewellers required about 13 million ounces. In 1982 U.S. silver consumption by silversmiths and jewellers was slightly over 13 million ounces. Higher metal prices accounted for the substantial drop in consumption by these industries since the silver content often constitutes a large portion of the cost. While silver prices remain relatively high significant increases in silver consumption by these industries is unlikely.

In addition to the photographic, electronic and jewellery and sterlingware the remaining 25 per cent of industrial silver is used mainly in: catalysts for chemical processing, mirrors, brazing alloys and solders, electroplating, dental amalgams, medical equipment bearings, chemicals coins, medallions and commemorative objects.

## PRICES

Silver prices increased in 1983, over 1982, but then lost much of this gain during 1984. The 1984 average London fixing dropped to $US 8.14 per oz from $US 11.45 in 1983. In 1982 the average had been $US 7.95. The price spread in 1984 between the high and low prices was $US 3.78. This compares to the much broader range of $US 6.30, which occurred in both 1983 and 1982.

## OUTLOOK

Canada's output of primary silver in 1985 is expected to be unchanged from 1984, although there will be some geographical shift in production. In the short- to medium-term Canadian silver production should continue near present levels, as there are no major mine developments on the horizon and little capacity is expected to be closed.

Worldwide silver production in 1985 may increase somewhat from 1984, especially if countries such as Mexico and Peru continue to exploit their silver resources for foreign exchange.

Silver bullion prices will remain depressed as long as high interest rates and low inflation divert investment dollars away from the precious metals market. However, longer-term silver prices are expected to remain in the $5 to $10 per oz ($US 1984).

While actual mine output will continue to fall below fabrication demand, industrial scrap recovery coupled with individual and government dishoarding will keep silver prices under pressure.

Silver usage is expected to either stabilize near current levels or grow by no more than 2.5 per cent per year, depending upon price. The industrial usage of silver accounts for about 55 per cent of its demand, however, in the longer term this portion could grow as silver moves away from its role as a financial investment.

**TARIFFS**

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| CANADA | | | (%) | | |
| 32900-1 | Ores of metals, nop | free | free | free | free |
| 35800-1 | Anodes of silver | free | free | 10 | free |
| 35900-1 | Silver in ingots, blocks, bars, drops, sheets or plates, unmanufactured; silver sweepings; scrap jewelery | free | free | free | free |
| 35905-1 | Scrap silver and metal alloy scrap containing silver | free | free | 25 | free |
| 36100-1 | Silver leaf | 12.5 | 15.7 | 30 | 10 |
| 36200-1 | Articles consisting wholly or in part of sterling or other silverware, nop; manufactures of silver, nop | 15.7 | 16.8 | 45 | 11 |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 36100-1 | 15.7 | 14.6 | 13.5 | 12.4 | 11.3 |
| 36200-1 | 16.8 | 15.3 | 13.9 | 12.4 | 11.0 |

UNITED STATES (MFN)

| | | |
|---|---|---|
| 601.39 | Precious metal ores, silver content | free |
| 605.20 | Silver bullion, silver dore and silver precipitates | free |
| 605.70 | Precious metal sweepings and waste and scrap, silver content | free |
| 644.56 | Silver leaf | 2.5¢ per 100 leaves |

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 420.60 | Silver compounds | 4.4 | 4.2 | 4.0 | 3.9 | 3.7 |
| 605.46 | Platinum-plated silver, unwrought or semi-manufactured | 11.8 | 10.7 | 9.6 | 8.6 | 7.5 |
| 605.47 | Gold-plated silver, unwrought or semi-manufactured | 17.5 | 15.6 | 13.8 | 11.9 | 10.0 |
| 605.48 | Other unwrought or semi-manufactured silver | 8.3 | 7.7 | 7.1 | 6.6 | 6.0 |
| 605.65 | Rolled silver, unworked or semi-manufactured | 8.3 | 7.7 | 7.1 | 6.6 | 6.0 |

**TARIFFS** (cont'd)

| Item No. | | 1983 | Base Rate | Concession Rate |
|---|---|---|---|---|
| EUROPEAN ECONOMIC COMMUNITY (MFN) | | | (%) | |
| 28.49 | Colloidal silver, amalgams, salts and other compounds of silver | | | |
| A. | Colloidal silver | 6.7 | 8.0 | 5.3 |
| B. | Amalgams of silver | 6.7 | 8.0 | 5.3 |
| C. | Salts and other compounds, inorganic or organic of silver | 7.8 | 9.6 | 6.0 |
| 71.05 | Silver, including silver gilt and platinum-plated silver, unwrought or semi-manufactured | | | |
| A. | Unwrought | free | free | free |
| B. | Bars, rods, wire and sections, plates, sheets, strips | 1.9 | 2.0 | 1.8 |
| C. | Tubes, pipes and hollow bars | 3.2 | 3.5 | 2.9 |
| D. | Foil of a thickness, excluding any backing, not exceeding 0.15 mm | 5.8 | 6.5 | 5.0 |
| E. | Powder, purls, spangles, cuttings and other forms | 4.4 | 5.0 | 3.8 |
| 71.06 | Rolled silver, unworked, or semi-manufactured | | | |
| A. | Unworked | 4.4 | 5.0 | 3.8 |
| B. | Semi-manufactured | 5.6 | 6.5 | 4.6 |
| 71.08 | Rolled gold on silver, unworked or semi-manufactured | 3.2 | 3.5 | 2.9 |
| 71.10 | Rolled platinum or other platinum group metals on silver, unworked or semi-manufactured | 3.2 | 3.5 | 2.9 |
| 71.11 | Silversmiths sweepings, residues and other waste and scrap | free | free | free |
| 71.12 | Articles of jewellery and parts thereof, of silver or rolled silver | | | |
| A. | Of silver | 4.0 | 4.5 | 3.5 |
| B. | Of rolled silver | 7.4 | 9.0 | 5.8 |
| 71.13 | Articles of silversmiths wares and parts thereof, of silver, other than above | | | |
| A. | Of silver | 5.3 | 7.5 | 3.0 |
| B. | Of rolled silver | 4.4 | 5.0 | 3.8 |
| 71.14 | Other articles of silver or rolled silver | | | |
| A. | Of silver | 6.0 | 7.5 | 5.1 |
| B. | Of rolled silver | 5.2 | 6.0 | 4.4 |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1983), USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, L318, Vol. 25, 1982.
nop Not otherwise provided for.

## TABLE 1. CANADA, SILVER PRODUCTION AND TRADE, 1982 AND 1983 AND CONSUMPTION, 1981 AND 1982

| | 1982 | | 1983P | | Jan.-Sept. 1984 | |
|---|---|---|---|---|---|---|
| | (kilograms) | ($000) | (kilograms) | ($000) | (kilograms) | ($000) |
| **Production**[1] | | | | | | |
| By province and territories | | | | | | |
| British Columbia | 499 000 | 157,579 | 411 000 | 185,793 | 355 617 | 124,315 |
| Ontario | 351 000 | 110,970 | 347 000 | 157,026 | 506 358 | 177,010 |
| New Brunswick | 230 000 | 72,719 | 210 000 | 94,965 | 136 463 | 47,704 |
| Northwest Territories | 51 000 | 16,073 | 51 000 | 22,993 | 50 000 | 17,564 |
| Quebec | 55 000 | 17,507 | 39 000 | 17,866 | 37 789 | 13,210 |
| Manitoba | 25 000 | 8,014 | 23 000 | 10,575 | 27 974 | 10,478 |
| Yukon | 95 000 | 29,943 | 18 000 | 8,155 | 43 898 | 15,346 |
| Saskatchewan | 5 000 | 1,471 | 5 000 | 2,222 | 4 868 | 1,702 |
| Newfoundland | 3 000 | 928 | 2 000 | 846 | 5 529 | 1,932 |
| Alberta | -- | -- | - | - | - | - |
| Nova Scotia | - | - | - | - | - | - |
| Total | 1 314 000 | 415,204 | 1 106 000 | 500,441 | 1 168 496 | 409,262 |
| By source[2] | | | | | | |
| Base-metal ores | 994 000 | 314,087 | 642 000 | 290,491 | .. | .. |
| Gold ores | 20 000 | 6,362 | 77 000 | 34,841 | | |
| Silver ores | 299 000 | 94,563 | 387 000 | 175,109 | | |
| Placer gold ores | 1 000 | 192 | .. | .. | | |
| Total | 1 314 000 | 415,204 | 1 106 000 | 500,441 | | |
| Refined silver[3] | 790 358 | .. | 1 047 512 | .. | | |
| **Exports** | | | | | | |
| Silver in ores and concentrates | | | | | | |
| Japan | 217 259 | 48,672 | 185 639 | 68,119 | 139 424 | 38,469 |
| United States | 163 120 | 38,531 | 89 751 | 32,831 | 89 761 | 24,751 |
| Belgium-Luxembourg | 97 487 | 17,453 | 93 937 | 28,639 | 16 187 | 3,097 |
| West Germany | 21 159 | 2,797 | 18 256 | 3,400 | 8 527 | 1,298 |
| Switzerland | - | - | 9 919 | 2,987 | 17 614 | 4,868 |
| Taiwan | 1 177 | 192 | 6 913 | 2,687 | 996 | 217 |
| Sweden | 7 503 | 2,326 | 5 971 | 2,327 | - | - |
| Other countries | 94 898 | 26,708 | 30 523 | 6,566 | 49 373 | 9,541 |
| Total | 602 603 | 136,679 | 440 909 | 147,556 | 321 882 | 82,231 |
| Refined metal | | | | | | |
| United States | 1 125 689 | 367,968 | 1 041 673 | 480,533 | 795 852 | 227,530 |
| Japan | - | - | 1 301 | 381 | - | - |
| Trinidad-Tobago | 538 | 186 | 779 | 378 | 210 | 85 |
| Brazil | 365 | 98 | 768 | 363 | - | - |
| Other countries | 7 755 | 2,126 | 1 345 | 516 | 453 | 165 |
| Total | 1 134 347 | 370,378 | 1 045 866 | 482,171 | 795 515 | 277,780 |
| **Imports** | | | | | | |
| Silver in ores and concentrates | | | | | | |
| Peru | 19 817 | 4,438 | 77 788 | 26,752 | .. | .. |
| Chile | 26 041 | 7,915 | 31 748 | 11,681 | | |
| United States | 40 989 | 10,642 | 24 887 | 8,326 | | |
| South Korea | 22 767 | 5,535 | 6 230 | 2,641 | | |
| South Africa | 31 399 | 5,933 | 5 806 | 1,860 | | |
| Other countries | 2 934 | 912 | 6 796 | 2,136 | | |
| Total | 143 947 | 35,375 | 153 255 | 53,396 | | |

TABLE 1. (cont'd)

| | 1982 | | 1983P | | Jan.-Sept. 1984 | |
|---|---|---|---|---|---|---|
| | (kilograms) | ($000) | (kilograms) | ($000) | (kilograms) | ($000) |
| Refined metal | | | | | | |
| United States | 256 309 | 76,606 | 280 496 | 125,377 | 163 194 | 53,751 |
| Chile | 16 000 | 4,673 | 33 496 | 16,106 | 7 999 | 3,198 |
| El Salvador | - | - | 16 325 | 7,410 | - | - |
| Japan | - | - | 3,225 | 1,583 | - | - |
| Mexico | 3 110 | 885 | 1 968 | 1,016 | 8 123 | 4,594 |
| United Kingdom | 207 877 | 66,814 | - | - | 402 | 38 |
| Others | 944 | 273 | 3 929 | 850 | 1 462 | 448 |
| Total | 484 240 | 149,251 | 339 439 | 152,342 | 181 180 | 62,029 |
| Consumption, by use | | | | | | |
| Sterling | 32 247 | .. | 12 108 | .. | .. | .. |
| Silver alloys | 41 105 | .. | 18 569 | .. | .. | .. |
| Wire rod | 3 527 | .. | 3 686 | .. | .. | .. |
| Others[4] | 215 251 | .. | 146 096 | .. | .. | .. |
| Total | 292 130 | .. | 180 459 | .. | .. | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; and base and other bullion produced from domestic ores. [2] Estimated by Energy, Mines and Resources Canada; the base-metal category includes production of some mines normally regarded as silver producers, but which also recover some base-metal. [3] From all sources, domestic and imported materials of both primary and secondary origin. [4] Includes sheet, coinage, fabricated investment bars and miscellaneous uses.
P Preliminary; - Nil; .. Not available; -- Amount too small to be expressed.

TABLE 2. CANADA, SILVER PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975, AND 1979-83

| | Production | | Exports | | | Imports, Refined Silver | Consumption[3] Refined Silver |
|---|---|---|---|---|---|---|---|
| | All Forms[1] | Refined[2] Silver | In Ores and Concentrates | Refined Silver | Total | | |
| | | | | (kilograms) | | | |
| 1970 | 1 376 354 | 955 668 | 678 676 | 752 689 | 1 431 365 | 134 347 | 187 679 |
| 1975 | 1 234 642 | 931 540 | 471 410 | 713 566 | 1 184 976 | 420 078 | 642 089 |
| 1979 | 1 146 908 | 949 770 | 415 726 | 911 146 | 1 326 872 | 38 308 | 251 985 |
| 1980 | 1 070 000 | 985 051 | 396 690 | 881 761 | 1 278 451 | 339 180 | 265 938 |
| 1981 | 1 129 394 | 875 121 | 546 449 | 914 800 | 1 461 249 | 327 328 | 292 130 |
| 1982 | 1 314 000 | 790 358 | 602 603 | 1 134 347 | 1 736 950 | 184 240 | 180 459 |
| 1983P | 1 106 080 | 1 047 512 | 440 909 | 1 045 866 | 1 486 775 | 339 439 | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; and base and other bullion produced from domestic ores. [2] From all sources, domestic and imported materials of both primary and secondary origin. [3] In some years includes only partial consumption for coinage.
P Preliminary; .. Not available.

### TABLE 3. WORLD MINE PRODUCTION[1] OF SILVER, 1982 AND 1983

| | 1982P | 1983[e] |
|---|---|---|
| | (kilograms) | |
| U.S.S.R.[e][2] | 1 458 000 | 1 465 000 |
| Mexico | 1 550 197 | 1 832 876 |
| Peru | 1 654 161 | 1 679 588 |
| Canada | 1 313 630 | 1 105 894 |
| United States | 1 251 572 | 1 252 731 |
| Australia | 900 290 | .. |
| Poland[e] | 654 987 | 653 173 |
| Chile | 382 197 | .. |
| Japan | 306 175 | 307 173 |
| Republic of South Africa | 216 001 | 172 909 |
| Bolivia | 170 188 | .. |
| Sweden | 167 829 | .. |
| Yugoslavia[e][2] | 103 979 | 124 012 |
| Spain | 117 843 | .. |
| Morocco | 52 345 | .. |
| Zaire | 59 239 | .. |
| South Korea | 44 906 | .. |
| Argentina | 82 735 | .. |
| Philippines | 61 689 | 56 699 |
| People's Republic of China | 70 035 | .. |
| Greece | 49 169 | .. |
| Italy | 55 701 | 73 482 |
| France | 30 663 | 21 410 |
| Other countries[e] | 797 924 | .. |
| Total | 11 551 455 | 12 130 356 |

Sources: Energy, Mines and Resources Canada; Nonferrous Metal Data 1983, American Bureau of Metal Statistics Inc.; Mineral Commodity Summaries 1984, U.S. Bureau of Mines.

[1] Recoverable content of ores and concentrates produced unless otherwise noted.
[2] Smelter and refinery production.
P Preliminary; [e] Estimated; .. Not available.

### TABLE 4. ANNUAL AVERAGE SILVER PRICES: CANADA, UNITED STATES AND UNITED KINGDOM, 1973-84

| | Canada | United States Handy & Harman, New York | United Kingdom London Spot |
|---|---|---|---|
| | ($Cdn) | ($US) | (pence) |
| | (per troy ounce) | | |
| 1973 | 2.567 | 2.558[1] | 103.783 |
| 1974 | 4.595 | 4.708 | 199.819 |
| 1975 | 4.503 | 4.419 | 200.118 |
| 1976 | 4.291 | 4.353 | 242.423 |
| 1977 | 4.922 | 4.623 | 265.512 |
| 1978 | 6.171 | 5.401 | 282.203 |
| 1979 | 12.974 | 11.094 | 519.607 |
| 1980 | 24.099 | 20.632 | 900.778 |
| 1981 | 12.617 | 10.518 | 515.303 |
| 1982 | 9.831 | 7.947 | 455.331 |
| 1983 | 14.154 | 11.441 | 753.644 |
| 1984 | 10.521 | 8.138 | |

Sources: Canadian prices as quoted in the Northern Miner (arithmetical average of daily quotations). United States and United Kingdom prices as quoted in Metals Week.

[1] The 60-day general price freeze in effect in the United States from June 13 through August 12, 1973 forced intermittent suspension of Handy & Harman's daily quotation during July and August for a total of 22 days.

### TABLE 5. UNITED STATES CONSUMPTION OF SILVER BY END-USE[1], 1982 AND 1983

| | 1982 | | 1983P | |
|---|---|---|---|---|
| | (kilograms) | (%) | (kilograms) | (%) |
| Electroplated ware | 101 211 | 2.7 | 97 696 | 2.7 |
| Sterling ware | 204 630 | 5.5 | 218 409 | 6.0 |
| Jewellery | 194 708 | 5.3 | 213 401 | 5.9 |
| Photographic materials | 1 610 196 | 43.7 | 1 611 813 | 44.3 |
| Dental and medical supplies | 52 503 | 1.4 | 47 557 | 1.3 |
| Mirrors | 30 170 | 0.8 | 30 108 | 0.8 |
| Brazing alloys and solders | 229 668 | 6.2 | 208 238 | 5.7 |
| Electrical and electronic products: | | | | |
| Batteries | 129 608 | 3.5 | 82 020 | 2.3 |
| Contacts and conductors | 862 499 | 23.3 | 817 151 | 22.4 |
| Bearings | 7 092 | 0.2 | 5 350 | 0.1 |
| Catalysts | 75 177 | 2.0 | 75 053 | 2.1 |
| Coins, medallions and commemorative objects | 56 982 | 1.5 | 92 657 | 2.5 |
| Miscellaneous[2] | 141 893 | 3.9 | 142 049 | 3.9 |
| Total net industrial consumption | 3 696 337 | 100.0 | 3 641 502 | 100.0 |
| Coinage[3] | 57 417 | | 66 188 | |
| Total consumption | 3 753 754 | | 3 707 690 | |

Sources: United States Bureau of Mines, Mineral Industry Surveys, "Gold and Silver in December 1983".

[1] End-use as reported by converters of refined silver. [2] Includes silver-bearing copper, silver-bearing lead anodes, ceramic paints, etc. [3] Includes silver used in minting the George Washington Commemorative Coin and the $1.00 Olympic Coin.

P Preliminary.

### TABLE 6. NON-COMMUNIST WORLD CONSUMPTION OF SILVER, 1982 AND 1983

| | 1982 | 1983P |
|---|---|---|
| | (kilograms)[1] | |
| **Industrial uses** | | |
| United States | 3 695 093 | 3 732 417 |
| Japan | 1 965 740 | 2 161 692 |
| West Germany | 1 045 077 | 799 359 |
| India | 699 828 | 678 056 |
| France | 578 525 | 578 525 |
| United Kingdom | 622 070 | 559 863 |
| Belgium | 469 662 | 497 656 |
| Italy | 289 262 | 342 138 |
| Canada | 279 931 | 279 931 |
| Mexico | 111 973 | 59 097 |
| Other countries | 1 088 621 | 1 135 276 |
| Total industrial uses | 10 845 782 | 10 824 010 |
| **Coinage** | | |
| Austria | 124 414 | 62 207 |
| United States | 77 759 | 348 359 |
| Canada | 9 331 | 12 441 |
| Other countries | 186 621 | 155 518 |
| Total coinage | 398 125 | 578 525 |
| Total consumption | 11 243 907 | 11 402 535 |

Source: Handy & Harman, The Silver Market, 1983.

[1] One kilogram equals 32.1507 troy ounces.

P Preliminary.

# Sodium Sulphate

G.S. BARRY

Sodium sulphate is mainly produced from natural brines and deposits in alkaline lakes in areas with dry climates and restricted drainage, from subsurface deposits and brines, or as a byproduct of chemical processes. Canada's sodium sulphate industry is based on extraction from natural brines and deposits in several alkaline lakes in Saskatchewan and Alberta. Nine plants producing natural sodium sulphate operated in Canada in 1983 and 1984. Byproduct sodium sulphate is recovered at one rayon plant and at three paper mills in Ontario. Production of byproduct sodium sulphate commenced in December 1982 at a new silver mine in British Columbia.

In the United States, natural and byproduct sodium sulphate production is almost evenly split. In Europe, sodium sulphate is produced almost entirely as a byproduct of chemical processes.

## PRODUCTION AND DEVELOPMENTS IN CANADA

Markets for sodium sulphate, which were strong for five consecutive years between 1978 and early 1983 started to decline by mid-1983 as the overall North American economy increased and additional secondary supplies became available. The Saskatchewan producers responded by decreasing production by 18 per cent between 1982 and 1983 and by decreasing a further 17 per cent between 1983 and 1984. The unit value of shipments was $86.69 per t in 1982; $93.92 in 1983; and $95.90 in 1984. Exports to the United States declined by 19 per cent for the first nine months of 1984 compared with the same period last year.

Besides natural sodium sulphate, about 90 000 tpy are produced as a byproduct of industrial and chemical processes in central Canada. Between 35 and 40 per cent of the total sodium sulphate produced in Canada is the higher-grade and higher-priced "detergent-grade".

Placer Development Limited brought on-stream the Equity Silver Mines Limited property in British Columbia in December 1982. The capacity of the plant is 5 000 tpy of sodium sulphate but much less was produced in 1983 and 1984.

A new use for sodium sulphate will be the production of potassium sulphate through a reaction of sodium sulphate with potassium chloride (glaserite process). Dry sodium sulphate is actually not needed so Glauber's salt will be used. The Potash Corporation of Saskatchewan announced in April 1983 that it will construct a "demonstration plant" having a capacity of 30 000 tpy at its Cory mine near Saskatoon. The plant is expected to be in production in mid-1985 and capital expenditures will be approximately $6.0 million. As of the end of 1984 construction was on schedule.

**Deposits.** The sodium sulphate deposits in Saskatchewan and Alberta have formed in shallow, undrained lakes and ponds where in-flow is greater than out-flow. Percolating ground waters carry dissolved salts into the basins from the surrounding soils. High rates of summer evaporation concentrate the brine to near saturation, and cooler fall temperatures cause crystallization and precipitation of sodium sulphate as mirabilite ($Na_2SO_4.10H_2O$). The cycle has been repeated year after year and thick deposits of hydrous sodium sulphate, accompanied by other salts and mud, have accumulated.

Deposits in Saskatchewan have been identified that contain, in total, approximately 90 million t of anhydrous sodium sulphate. Of this amount, a total of about 51 million t is in 21 individual deposits, each containing more than 500 000 t of sodium sulphate. Exploitation currently takes place on the following lakes (with reserves, in millions of t, in brackets): Whitehorse Lake (6.5), Horseshoe Lake (3.7), Frederic Lake (2.4), Chaplin Lake (3.0), Ingebrigt Lake (9.0),

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Alsack Lake (2.6), East Coteau Lake (3.5), and Snakehole Lake (1.7), all in Saskatchewan. Production in Alberta is from Horseshoe Lake (2.0). For Saskatchewan, the reserves calculations were made in 1978 and for Alberta in 1982. Since that time reserves changed only marginally.

**Recovery and processing.** Because sodium sulphate is recovered by evaporation of concentrated brines or by dredging of the permanent beds of crystals, weather is as important for recovery of sodium sulphate as it is for its deposition. A large supply of fresh water is also essential. One method of sodium sulphate recovery is to pump lake brines that have been concentrated by hot summer weather into evaporating ponds or reservoirs. Continued evaporation produces a saturated or near-saturated solution of mirabilite. Differential crystallization occurs in the fall when the solution cools. Hydrous sodium sulphate crystallizes and precipitates, whereas sodium chloride, magnesium sulphate and other impurities remain in solution. Before freezing weather sets in, the impure solution remaining in the reservoir is drained or pumped back into the source lake. After the crystal bed has become frozen, harvesting is carried out using conventional earthmoving equipment. The harvested crystal is stockpiled adjacent to the plant.

Some operators use floating dredges to mine the permanent crystal bed. The slurry of crystal and brine is transported to a screening house at the plant by pipeline. If sufficiently concentrated, the brine from the screens is collected in an evaporation pond.

One company uses a combination of dredging and solution mining, and pumps a concentrated brine to an air-cooled crystallizer at the plant, where sodium sulphate is separated from other insoluble salts.

Processing of a natural salt consists of dehydration (Glauber's salt contains 55.9 per cent water of crystallization) and drying. Commercial processes used in Saskatchewan include Holland evaporators, gas-fired rotary kilns, submerged combustion and multiple effect evaporators. Salt cake, the product used principally in the pulp and paper industry, contains a minimum of 97 per cent $Na_2SO_4$. Detergent-grade material analyzes up to 99.7 per cent $Na_2SO_4$. Uniform grain size and free-flow characteristics are important in material handling and use.

Of the nine plants in the prairies, three are capable of producing detergent-grade sodium sulphate. Each of the three plants has the capacity to produce 80 per cent or more of its output as a high-grade product. The "natural" sodium sulphate industry employs about 300 persons.

**Byproduct recovery.** Courtaulds (Canada) Inc. produces approximately 21 000 t of detergent-grade sodium sulphate as a byproduct of viscose rayon production at its Cornwall, Ontario plant. Ontario Paper Company Limited at Thorold, Ontario produced 47 200 t of salt cake in 1983 and approximately 60 000 t in 1984 as a byproduct of paper manufacturing. It is mostly used in the glass industry and 60 per cent is exported. The capacity of the Thorold plant is 77 000 tpy. The Great Lakes Paper Company, Limited at Thunder Bay, produces salt cake for internal consumption (about 10 000 t in 1984).

## PRICES

Canadian prices of sodium sulphate were $75 and $95 per t respectively for salt cake and detergent-grade at the beginning of 1983. The prices increased to $81 and $101 per t in April 1983 and remained at this level throughout the rest of 1983 and 1984. Prices for detergent-grade byproduct sodium sulphate in Ontario were in the order of $155 to $170 per t (for bulk) fob plants in the beginning of 1983, but decreased by $20 to $30 per t since that time.

## USES

In the chemical pulping of wood the digestion reagents consist of about two-thirds caustic soda and one-third sodium sulphide obtained by using sodium sulphate as makeup. About 33 per cent of sulphur input is retained in the organic chemicals recycled in the process. Lately, technical improvements in the process significantly decreased the consumption of sodium sulphate per t of pulp produced, to about 20 kg/t. More caustic soda and emulsified sulphur is being substituted for salt cake.

Sodium sulphate is used as a builder; or more correctly as a diluent in detergents (supplies "bulk"); it is claimed to improve detergency through its effect on the colloidal properties of the cleaning system. The curtailment in the usage of phosphates on grounds of pollution control in all probability is not going to affect the use of sodium sulphate. The content of sodium sulphate in detergents varies from about 10 to 65 per cent. Roskill Information Services Ltd., suggests that as a very rough estimate sodium sulphate used in detergents of all types would represent some 10 per cent of world consumption.

Some sodium sulphate is used by the glass industry as a source of $Na_2O$ to speed melting. Other end uses of sodium sulphate are in the dyeing industry in the manufacture of viscose sponges, the tanning industry and textiles.

An important new use is linked to pollution abatement measures: sodium sulphate is added to coal as a conditioner, since it improves the efficiency of high-temperature electrostatic precipitators by preventing clogging by fly-ash. Only about 5 kg of sodium sulphate (worth about 50 cents) is used for a tonne of coal. Experiments are being conducted in using sodium sulphate as a heat storage medium in solar energy conservation (heating) projects.

## OUTLOOK

Outlook for the Canadian production and sales of natural sodium sulphate in 1985 is not very good. As a result of increased industrial activity, secondary supplies (byproduct sodium sulphate) are plentiful. Furthermore, perhaps as much as 200 000 t of sodium sulphate used by the North American pulp and paper industry was substituted by caustic soda and emulsified sulphur. Caustic prices are very erratic but are currently low; emulsified sulphur may be more expensive but the product is easier to handle.

The longer-term growth in sodium sulphate demand in North America will come mainly from the detergent industry sector (2 per cent to 3 per cent increase per year), although there are indications that the growth in this market may be temporarily levelling off in 1985, and possibly the power industry, where sodium sulphate is increasingly used as a conditioner in coal burning thermal plants. In the United States this new market has the potential to expand substantially perhaps up to 300 000 tpy in the late 1980s, or early 1990s.

U.S. commodity experts, however, still forecast none or little growth in the United States for sodium sulphate consumption in the decade of the 1980s since consumption in many traditional sectors is declining.

TABLE 1. CANADA, SODIUM SULPHATE PRODUCTION AND TRADE, 1982-84

| | 1982 | | 1983P | | 1984 | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($) | (tonnes) | ($) | (tonnes) | ($) |
| **Production** | | | | | | |
| Shipments | | | | | | |
| Saskatchewan | .. | 43,777,000 | .. | 38,441 000 | .. | 32,797,000 |
| Alberta | .. | 3,681,000 | .. | 3,895,000 | .. | 4,133,000 |
| British Columbia | .. | 4,000 | .. | 300,000 | .. | 146,000 |
| Total | 547 000 | 47,462,000 | 453 939 | 42,636,000 | 386 600 | 37,076,000 |
| | | | | | (Jan.-Sept. 1984) | |
| **Imports** | | | | | | |
| Total salt cake and Glauber's salt | | | | | | |
| United Kingdom | 16 381 | 1,107,000 | 21 715 | 1,497,000 | 15 749 | 939,000 |
| United States | 912 | 234,000 | 713 | 259,000 | 424 | 174,000 |
| West Germany | - | - | 51 | 5,000 | 56 | 17,000 |
| Total | 17 293 | 1,341,000 | 22 479 | 1,761,000 | 16 229 | 1,131,000 |
| **Exports** | | | | | | |
| Crude sodium sulphate | | | | | | |
| United States | 355 904 | 34,279,000 | 265 525 | 28,718,000 | 170 799 | 18,605,000 |
| New Zealand | 10 891 | 1,016,000 | - | - | - | - |
| Other countries | 1 129 | 206,000 | 227 | 27,000 | - | - |
| Total | 367 924 | 35,501,000 | 265 752 | 28,745,000 | 170 799 | 18,605,000 |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
P Preliminary; .. Not available; - Nil.

TABLE 2. CANADA, NATURAL SODIUM SULPHATE PLANTS, 1982

| | Plant Location | Source Lake | Annual Capacity (tonnes) |
|---|---|---|---|
| **Alberta** | | | |
| Agassiz Resources Limited | Metiskow | Horseshoe | 75 000 |
| **Saskatchewan** | | | |
| Hudson Bay Mining and Smelting Co., Limited | Grant | Snakehole | 63 000 |
| Hudson Bay Mining and Smelting Co., Limited | Hardene | Alsask | 42 500 |
| Miller Western Industries Limited | Palo | Whiteshore | 109 000 |
| Ormiston Mining and Smelting Co., Ltd. | Ormiston | Horseshoe | 90 700 |
| Saskatchewan Minerals | Chaplin | Chaplin | 90 000 |
| Saskatchewan Minerals | Bishopric | Frederick | 45 000 |
| Saskatchewan Minerals | Fox Valley | Ingebrigt | 135 000 |
| Saskatchewan Minerals[1] | Gladmar | East Coteau | 45 500 |
| Total | | | 695 600 |

Source: Company reports.
[1] Since Oct. 1980; formerly Sybouts Sodium Sulphate Co., Ltd.

### TABLE 3. CANADA, SODIUM SULPHATE PRODUCTION, TRADE AND CONSUMPTION 1970, 1975, 1979-84

| | Production[1] | Imports[2] | Exports | Consumption |
|---|---|---|---|---|
| | (tonnes) | | | |
| 1970 | 445 017 | 26 449 | 108 761 | 291 439 |
| 1975 | 472 196 | 22 638 | 178 182 | 256 385 |
| 1979 | 443 279 | 23 156 | 193 268 | 255 059 |
| 1980 | 496 000 | 20 211 | 245 831 | 232 045 |
| 1981 | 535 000 | 24 960 | 284 281 | 216 298r |
| 1982 | 547 000 | 17 293 | 367 924 | 195 341 |
| 1983 | 453 939 | 22 479 | 265 752 | 191 618 |
| 1984 | 386 600P | .. | .. | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments of crude sodium sulphate. [2] Includes Glauber's salt and crude salt cake.
P Preliminary; .. Not available;
r Revised.

### TABLE 5. CANADA, RAILWAY TRAIN LOADINGS OF SODIUM SULPHATE, 1982 AND 1983

| | 1982 | 1983 |
|---|---|---|
| | (tonnes) | |
| Eastern Canada[1] | 37 483 | 39 970 |
| Western Canada[2] | 515 476 | 413 463 |
| Total Canada | 552 959 | 453 433 |

Source: Statistics Canada.
[1] Eastern Canada refers to provinces east of the Ontario-Manitoba border. [2] Final figure has been adjusted to reflect a recalculation of data.

### TABLE 4. CANADA, AVAILABLE DATA ON SODIUM SULPHATE CONSUMPTION, 1981-83

| | 1981r | 1982 | 1983 |
|---|---|---|---|
| | (tonnes) | | |
| Pulp and paper | 158 927 | 142 281 | 141 172 |
| Soaps | 40 855 | 38 437 | 40 219 |
| Glass and glass wool | 12 001 | 11 286 | 9 551 |
| Other products[1] | 4 515 | 3 337 | 676 |
| Total | 216 298 | 195 341 | 191 618 |

Source: Energy, Mines and Resources Canada.
[1] Colours, pigments, feed supplements and other minor uses.
r Revised.

# Stone

### D.H. STONEHOUSE

## SUMMARY

Increased demand for dimension stone to supply the building construction market in the United States has created a renewed interest in the building stone resources in many Canadian provinces. Since 1982 the strong United States dollar has maintained the competitiveness of many imported materials, among them dimension stone finished at more modern European plants. Under such conditions, to establish costly new technology in the United States to produce from domestic sources is not attractive. However, European technology has been set up in Canada to finish both domestic and imported stone for subsequent shipment to the United States. Granicor Inc. brought European sawing and polishing expertise to Quebec in 1982 and has encouraged the production of native stone to the extent that six new granite quarries were opened in Quebec during 1983. The technique of using gang-saws to produce thin panels from large blocks and of applying these panels to steel or concrete construction units to provide aesthetically-pleasing, well-engineered structures, at costs competitive with other cladding, has enabled Granicor and others to avail themselves of a growing United States market for such material. A similar plant is to be established in Cornwall, Ontario by Karnuk Marble Industries Inc., again with the intention of supplying a portion of the demand in the United States. RPS Marbre Ltée of Montreal announced in late-1984 its intention to spend $9.2 million to expand and modernize its stone finishing facilities to enable greater production of marble, travertine and granite panels, mainly for the United States markets. The program will be assisted by a grant of $1.8 million from la Société de développement industriel du Québec.

A number of provinces intend to assess their building stone resources and to determine whether or not markets exist within reach of prospective quarry and plant sites. Studies will be undertaken in some instances under a new round of federal-provincial mineral subagreements as part of the Economic and Regional Development Agreements (ERDA).

Granite, limestone, marble and sandstone are the principal rock types from which building and ornamental stone is fashioned. Over 90 per cent is used in construction-oriented projects, while less than 10 per cent is used as monument stone. Imports of rough blocks, particularly of granite, for sawing and polishing, as well as of finished stones for distribution to retailers, have cut into markets formerly supplied from domestic sources.

## CANADIAN DEVELOPMENTS

Production of stone of all types increased by 14 per cent in 1983 to over 67 million t and by a further 5 per cent in 1984 to over 71 million t. These increases are attributed mainly to output from Ontario and Quebec. Stone is produced in direct response to the demands of the construction industry, which utilizes 93 per cent of output principally as crushed stone. Less than 1 per cent of stone production is used as building stone. Since 1979, there has been a growing interest in Canadian stone for building use. Shipments of granite from Quebec, especially black anorthosite, red granite and brownish monzonite, for modular panelling have shown marked increase. The chemical uses are limited to the cement, lime, glass and metal smelting industries and account for about 3 per cent of stone production, mainly limestone. The remaining 3 per cent is consumed in pulverized form as filler and extender materials, and for agricultural purposes.

Most provinces have accumulated data relative to occurrences of stone of all types and in many cases have published this information. The federal government, through the Geological Survey of Canada, has also gathered and published a great

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number of geological papers pertaining to stone occurrences. Works by W.A. Parks[1] and by M.F. Goudge[2] have become classics in the fields of building stones and limestones, respectively.

**Atlantic provinces.** Limestone. The many occurrences of limestone in the Atlantic provinces have been systematically catalogued during the past few years[3,4,5]. Deposits of commercial importance are being worked in three of the four provinces.

In Newfoundland limestone is available from small, impure exposures in the eastern portion of the island, from small, high-calcium deposits in the central region, and from large, high-purity, high-calcium occurrences in the west. Other than periodic operation to secure aggregate for highway work, the main exploitation is by North Star Cement Limited at Corner Brook[6]. Large quantities of high-calcium limestone have been outlined in the Port au Port district.

In Nova Scotia limestone occurs in the central and eastern parts of the province and in New Brunswick is quarried at three locations - Brookville, Elm Tree and Havelock - for use as a crushed stone, as an aggregate, for agricultural application, for cement and lime manufacture, and for use as a flux.

Granite. Occurrences of granite in the Atlantic region have been described by Carr[7]. In Nova Scotia, a grey granite is produced from operations near Nictaux and from one quarry at Shelburne for use mainly in the monument industry. A black granite from Shelburne and a diorite from Erinville have been used for monuments and for dimension stone.

Granite is quarried intermittently from a number of deposits in New Brunswick to obtain stone of required colour and texture for specific application. A red, fine- to medium-grained granite is quarried near St. Stephen, and fine-grained, pink, grey and blue-grey granites are available in the Hampstead (Spoon Island) district. In the Bathurst area, a brown-to-grey, coarse-grained granite is quarried upon demand, as is a salmon-coloured, medium-grained granitenear Antinouri Lake, and a black, ferromagnesian rock in the Bocabec River area. Red granite is available in the St. George district. Manufacturers of monument stone continue to import dark, crude granite from South Africa.

In Newfoundland, there is a recognized potential for the development of labradorite deposits in the Nain River area of Labrador.

Sandstone. A medium-grained buff sandstone is quarried at Wallace, Nova Scotia, for use as heavy riprap and for dimension stone applications.

In New Brunswick, a red, fine- to medium-grained sandstone has been quarried in Sackville for use in construction. Deposits are exploited from time to time throughout Kent and Westmorland counties for local projects and for highway work.

**Quebec.** Limestone. Limestone occurs in the St. Lawrence and Ottawa River valleys and in the Eastern Townships. Other major deposits in the province are located in the Gaspé region. The limestones range in age from Precambrian to Carboniferous and vary widely in purity, colour, texture and chemical composition[2]. Limestone blocks and other shapes are produced for the construction trade in the Montreal region and at various locations throughout the province as the need arises. Marble has been produced in the Eastern Townships and the Lac St-Jean areas.

Granite. Quebec, the major Canadian granite producer, accounts for up to 95 per cent of total granite shipments for use as building stone. Since 1979, sales have increased due to improved marketing and advanced processing technology. More than 25 companies quarry granite in Quebec, mainly in the Rivière-à-Pierre, the Lac St-Jean and the Appalachians regions. Six new quarries became operational in 1983 - two at Rivière-à-Pierre, two at Saint Alexis and two in the Rouyn region. Granicor Inc., using advanced technology for cutting and polishing dimension stone, produces brownish monzonite modular block panels from material extracted near the Chamouchouane River in the Lac St-Jean area. Capacity was expanded during 1983. A. Lacroix et fils Granit also expanded cutting and polishing capacity in 1983. In 1983, the North Shore of the St. Lawrence River was investigated by provincial government geologists.[8]

Sandstone. Of six operations producing from sandstone resources in Quebec only one is listed as marketing flagstone and construction blocks, in Hemmingford, Huntingdon County.

**Ontario.** Limestone. Although limestones in Ontario range from Precambrian through Devonian, the major production comes from Ordovician, Silurian and Devonian deposits[9,10]. Of particular importance are the limestones and dolomite from the following geological sequences: the Black River and Trenton formations, extending from the lower end of Georgian Bay across southern Ontario to Kingston; the Guelph-Lockport Formation, extending from Niagara Falls to the Bruce Peninsula and forming the Niagara Escarpment; and the Middle Devonian limestone extending from Fort Erie through London and Woodstock to Lake Huron. Production of building stone, fluxstone and crushed aggregate from the limestones of these areas normally accounts for about 90 per cent of total stone production in Ontario.

Marble is widely distributed over southeastern Ontario and, according to the Ontario Ministry of Natural Resources reports, underlies as much as 250 square kilometres (km$^2$)[11].

Steep Rock Calcite, a division of Steep Rock Iron Mines Limited, produces medium- to high-grade calcium carbonate at Tatlock and Perth. The filler markets have become extremely attractive recently, not only to new ventures but also to companies hitherto interested in production of only coarser aggregate materials.

Granite. Granites occur in northern, northwestern and southeastern Ontario[12,13]. Few deposits have been exploited for the production of building stone because the major-consuming centres are in southern and southwestern Ontario where ample, good-quality limestones and sandstones are readily available. The areas most active in granite building stone production have been the Vermilion Bay area near Kenora, the River Valley area near North Bay, and the Lyndhurst-Gananoque area in southeastern Ontario. Rough building blocks were quarried from a gneissic rock near Parry Sound, while at Havelock a massive red-granite rock was quarried. In 1982, Fairmont Granite Limited of Beebe, Quebec, reopened a fine pink granite quarry in Belmont Township for the production of building stone for modular block panels. A study to assess building stone and other industrial minerals in the northwestern region was arranged between the Ontario and the federal governments under the Northern Ontario Rural Development Agreement. A preliminary report of the Building and Ornamental Stone Inventory (open file report 5446) was released in 1984 by the Ontario Geological Survey.

Sandstone. Sandstone quarried near Toronto, Ottawa and Kingston has been used widely in Ontario as building stone[14]. Medina sandstones vary from grey, through buff and brown to red, and some are mottled. They are fine- to medium-grained. The Potsdam stone is medium-grained; the colour ranges from grey-white through salmon-red to purple, and it can also be mottled. Current uses are as rough building stone, mill blocks from which sawn pieces are obtained, ashlar, flagstone and as a source of silica for ferrosilicon and glass.

**Western provinces.** Limestone. From east to west through the southern half of Manitoba rocks of the following ages are represented: Precambrian, Ordovician, Silurian, Devonian and Cretaceous. Limestones of commercial importance occur in the three middle periods and range from magnesian limestone through dolomite to high-calcium limestones[2,15].

Although building stone does not account for a large percentage of total limestone produced, the best known Manitoba limestone is Tyndall Stone, a mottled dolomitic limestone often referred to as "tapestry" stone. It is widely accepted as an attractive building stone, and is quarried at Garson, Manitoba, about 50 km northeast of Winnipeg. Limestone from Moosehorn, 160 km northwest of Winnipeg and from Mafeking, 40 km east of the Saskatchewan border and 160 km south of The Pas, is transported to Manitoba and Saskatchewan centres for use in the metallurgical, chemical, agricultural and construction industries.

The eastern ranges of the Rocky Mountains contain limestone spanning the geologic ages from Cambrian to Triassic, with major deposits in the Devonian and Carboniferous periods in which a wide variety of types occur[16]. In southwestern Alberta, high-calcium limestone is mined at Exshaw, Kananaskis and Crowsnest, chiefly for the production of cement and lime, for metallurgical and chemical uses and for use as a crushed stone. Similar uses are made of limestone quarried at Cadomin, near Jasper[6].

In British Columbia large volumes of limestone are mined each year for cement and lime manufacture, for use by the pulp and paper industry and for various construction applications[6]. Deposits on Aristazabal Island have been developed for the export market. Other operations at Terrace, Clinton, Westwold, Popkum, Dahl Lake, Doeye River and Cobble Hill produced stone for construction and for filler use[17]. Periodically, interest is revived in the possible use of travertine from a British Columbia source.

Granite. In Manitoba, at Lac du Bonnet northeast of Winnipeg, a durable, red granite is quarried for building and monument use. Grey granite located east of Winnipeg near the Ontario border is a potential source of building stone.

In British Columbia a light-grey, to blue-grey even-grained granodiorite of medium texture is available from Nelson Island. An andesite has been quarried at Haddington Island, off the northeast coast of Vancouver Island, for use as a building stone. Babette Lake Quartzite Products Ltd. produces blocks of massive pink quartzite to make cut and polished facing stone.

Sandstone. Sandstone for building and ornamental uses, quarried near Banff, Alberta is hard, fine-grained, medium-grey and is referred to as "Rundal Stone".

## USES

Limestones are widely distributed in Canada and generally are available in sufficient quantity and with such chemical or physical specifications that long transportation hauls are unnecessary. Limestone products are low-priced commodities and only rarely, when a market exists for a high-quality, specialized product such as white portland cement or a high-purity extender, are they beneficiated or moved long distances. Provided the specifications are met, the nearest source is usually considered, regardless of provincial or national boundaries.

Some major uses in the chemical field are: neutralization of acid waste liquors; extraction of aluminium oxide from bauxite; manufacture of soda ash, calcium carbide, calcium nitrate and carbon dioxide; in pharmaceuticals; as a disinfectant; in the manufacture of dyes, rayons, paper, sugar and glass; and in the treatment of water. Dolomitic limestone is used in the production of magnesium chloride and other magnesium compounds.

Agricultural limestone is used to control soil acidity and to add calcium and magnesium to the soil. Limestone and lime are used as soil stabilizers, particularly on highway construction projects.

Dolomite is the source of magnesium metal produced at Haley, Ontario; the company also uses a high-calcium lime from southeastern Ontario in the production of calcium metal. Dead-burned dolomitic limestone for use as a refractory is produced at Dundas, Ontario, by Steetley Industries Limited.

As a dimension stone, granite is processed for interior and exterior floor- and wall-covering, modular block panelling and for monument stone. Uniformity of colour and texture, and durability are the main features sought. Quarrying must take into account geological and structural features as well as topography and accessibility.

## OUTLOOK

Dimension stone has been the subject of periodic surges of interest in past years. Currently the industry, especially in Quebec, is in a period of significant growth. Completion of intensive modernization has permitted producers to offer high-quality finished products at competitive prices. Markets for building stone are still under pressure from competitive substitutes such as steel, concrete, glass and ceramics. However, for aesthetic reasons and particular physical characteristics, the demand for granite dimension stone is likely to expand as new markets are developed and producers increase capacity. Efforts have been made on behalf of the industry to illustrate to contractors and architects the availability of a wide range of Canadian building stones and their adaptability in modern building design.

There is justifiable concern for the future development, operation, and rehabilitation of pits and quarries in all locations, especially in and near areas of urban development. Rehabilitation of stone quarries for subsequent land use is generally more difficult and costly than rehabilitation of gravel pits. Although an open-pit mining operation close to residential areas is seldom desirable, nonrenewable mineral resources must be fully and wisely utilized. When urban sprawl has been unexpectedly rapid, conflicts for land use can materialize and potential sources of raw mineral materials for the construction industry can be overrun. Master plans for land use are required to coordinate all phases of development so that mineral exploitation is part of the urban growth pattern.

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| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| CANADA | | | | | |
| 29635-1 | Limestone, not further processed than crushed or screened | free | free | 25 | free |
| 30500-1 | Flagstone, sandstone and all building stone, not hammered, sawn or chiselled | free | free | 20 | free |
| 30505-1 | Marble, rough, not hammered or chiselled | free | free | 20 | free |
| 30510-1 | Granite, rough, not hammered or chiselled | free | free | 20 | free |
| 30515-1 | Marble, sawn or sand rubbed, not polished | free | 4.5 | 35 | free |
| 30520-1 | Granite, sawn | free | 6.5 | 35 | free |
| 30525-1 | Paving blocks of stone | free | 6.5 | 35 | free |
| 30530-1 | Flagstone and building stone, other than marble or granite, sawn on not more than two sides | free | 6.5 | 35 | free |
| 30605-1 | Building stone, other than marble or granite, sawn on more than two sides but not sawn on more than four sides | 5 | 6.5 | 10 | 4.5 |
| 30610-1 | Building stone, other than marble or granite, planed, turned, cut or further manufactured than sawn on four sides | 7.5 | 10.3 | 15 | 6.5 |
| 30615-1 | Marble, not further manufactured than sawn, when imported by manufacturers of tombstones to be used exclusively in the manufacture of such articles, in their own factories | free | free | 20 | free |
| 30700-1 | Marble, nop | 11.1 | 11.1* | 40 | 7.0 |
| 30705-1 | Manufactures of marble, nop | 11.1 | 11.1* | 40 | 7.0 |
| 30710-1 | Granite, nop | 14.8 | 13.9 | 40 | 9.0 |
| 30715-1 | Manufactures of granite, nop | 14.8 | 13.9 | 40 | 9.5 |
| 30800-1 | Manufactures of stone, nop | 15.6 | 15.0 | 35 | 10.0 |
| 30900-1 | Roofing slate, per square of 100 square feet | free | free | 75¢ | free |
| 30905-1 | Granules, whether or not coloured or coated, for use in manufacture of roofing, including shingles and siding | free | free | 25 | free |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 30515-1 | 4.5 | 4.4 | 4.3 | 4.1 | 4.0 |
| 30520-1 | 6.5 | 6.3 | 6.0 | 5.8 | 5.5 |
| 30525-1 | 6.5 | 6.3 | 6.0 | 5.8 | 5.5 |
| 30530-1 | 6.5 | 6.3 | 6.0 | 5.8 | 5.5 |
| 30605-1 | 6.5 | 6.3 | 6.0 | 5.8 | 5.5 |
| 30610-1 | 10.3 | 9.7 | 9.1 | 8.6 | 8.0 |
| 30700-1 | 13.3 | 12.2 | 11.1 | 10.1 | 9.0 |
| 30705-1 | 13.3 | 12.2 | 11.1 | 10.1 | 9.0 |
| 30710-1 | 13.9 | 12.9 | 12.0 | 11.1 | 10.2 |
| 30715-1 | 13.9 | 12.9 | 12.0 | 11.1 | 10.2 |
| 30800-1 | 15.0 | 14.4 | 13.8 | 13.1 | 12.5 |

**TARIFFS** (cont'd)

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| UNITED STATES (MFN) | | | | | |
| | Granite, suitable for use as monumental, paving or building stone: | | | | |
| 513.71 | Not pitched, not lined, not pointed, not hewn, not sawed, not dressed, not polished, and not otherwise manufactured | | Free | | |

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 513.74 | Pitched, lined, pointed, hewn, sawed, dressed, polished, or otherwise manufactured | 5.1 | 4.9 | 4.7 | 4.4 | 4.2 |
| | Limestone, suitable for use as monumental, paving or building stone: | | | | | |
| 514.21 | Not hewn, not sawed, not dressed, not polished, and not otherwise manufactured, per cubic foot | 0.5¢ | 0.4¢ | 0.2¢ | 0.1¢ | free |
| 514.24 | Hewn, sawed, dressed, polished, or otherwise manufactured | 8.3 | 7.7 | 7.1 | 6.6 | 6.0 |
| 514.51 | Marble, breccia, in block, rough or squared only, per cubic foot | 12.7¢ | 12.6¢ | 12.4¢ | 12.2¢ | 12.0¢ |
| 514.57 | Marble, breccia, or onyx, sawed or dressed, over 2 inches thick, per cubic foot | 22.5¢ | 21.9¢ | 21.2¢ | 20.6¢ | 20.0¢ |
| | Stone suitable for use as monumental, paving, or building stone: | | | | | |
| 515.51 | Not hewn, not sawed, not dressed, not polished, and not otherwise manufactured, per cubic foot | 0.5¢ | 0.4¢ | 0.2¢ | 0.1¢ | free |
| 515.54 | Hewn, sawed, dressed, polished, or otherwise manufactured, per cubic foot | 8.3¢ | 7.7¢ | 7.1¢ | 6.6¢ | 6.0¢ |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1983) USITC Publication 1317; U.S. Federal Register, Vol. 44, No. 241.

* Temporary rate reduction until December 31, 1984.

## TABLE 1. CANADA, TOTAL PRODUCTION OF STONE, 1982-84

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (000 t) | ($000) | (000 t) | ($000) | (000 t) | ($000) |
| **By province** | | | | | | |
| Newfoundland | 357 | 1,763 | 279 | 1,431 | 415 | 1,608 |
| Nova Scotia | 679 | 4,638 | 1 296 | 7,784 | 1 510 | 9,400 |
| New Brunswick | 2 261 | 11,556 | 2 087 | 11,310 | 2 005 | 10,940 |
| Quebec | 25 060 | 106,989 | 27 303 | 121,154 | 28 237 | 124,581 |
| Ontario | 23 582 | 100,278 | 27 843 | 122,272 | 29 500 | 131,335 |
| Manitoba | 2 345 | 11,670 | 1 137 | 5,452 | 1 675 | 9,300 |
| Alberta | 264 | 3,161 | 286 | 3,457 | 300 | 3,275 |
| British Columbia | 4 310 | 21,926 | 4 915 | 27,083 | 4 885 | 27,500 |
| Northwest Terrtories | 323 | 1,268 | 2 409 | 14,601 | 2 420 | 15,750 |
| Canada | 59 181 | 263,249 | 67 555 | 314,544 | 71 047 | 333,689 |
| **By use**[1] | | | | | | |
| Building stone | | | | | | |
| Rough | 230 | 4,828 | .. | .. | .. | .. |
| Monumental and ornamental stone | 38 | 4,002 | .. | .. | .. | .. |
| Other (flagstone, curbstone, paving blocks, etc.) | 26 | 1,027 | .. | .. | .. | .. |
| Chemical and metallurgical | | | | | | |
| Cement plants, foreign | 598 | 1,461 | .. | .. | .. | .. |
| Lining, open-hearth furnaces | 38 | 141 | .. | .. | .. | .. |
| Flux in iron and steel furnaces | 742 | 2,861 | .. | .. | .. | .. |
| Flux in nonferrous smelters | 114 | 1,126 | .. | .. | .. | .. |
| Glass factories | 169 | 2,271 | .. | .. | .. | .. |
| Lime kilns, foreign | 512 | 1,903 | .. | .. | .. | .. |
| Pulp and paper mills | 295 | 2,706 | .. | .. | .. | .. |
| Sugar refineries | 108 | 586 | .. | .. | .. | .. |
| Other chemical uses | 137 | 2,840 | .. | .. | .. | .. |
| Pulverized stone | | | | | | |
| Whiting (substitute) | 71 | 2,863 | .. | .. | .. | .. |
| Asphalt filler | 41 | 238 | .. | .. | .. | .. |
| Dusting, coal mines | 7 | 171 | .. | .. | .. | .. |
| Agricultural purposes and fertilizer plants | 1 037 | 10,562 | .. | .. | .. | .. |
| Other uses | 687 | 2,153 | .. | .. | .. | .. |
| Crushed stone for | | | | | | |
| Manufacture of artificial stone | 7 | 154 | .. | .. | .. | .. |
| Roofing granules | 253 | 16,776 | .. | .. | .. | .. |
| Poultry grit | 28 | 721 | .. | .. | .. | .. |
| Stucco dash | 15 | 993 | .. | .. | .. | .. |
| Terrazzo chips | 3 | 184 | .. | .. | .. | .. |
| Rock wool | - | - | .. | .. | .. | .. |
| Rubble and riprap | 1 730 | 6,421 | .. | .. | .. | .. |
| Concrete aggregate | 4 671 | 17,571 | .. | .. | .. | .. |
| Asphalt aggregate | 4 540 | 17,766 | .. | .. | .. | .. |
| Road metal | 17 997 | 62,795 | .. | .. | .. | .. |
| Railroad ballast | 2 626 | 12,823 | .. | .. | .. | .. |
| Other uses | 22 461 | 80,318 | .. | .. | .. | .. |
| Total | 59 181 | 258,261 | .. | .. | .. | .. |

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[1] The 1982 value of production includes companies' transportation costs not applicable in the by use category.

P Preliminary; .. Not available; - Nil.

## TABLE 2. CANADA, PRODUCTION OF LIMESTONE, 1981 AND 1982

| | 1981 | | 1982 | |
|---|---|---|---|---|
| | (000 t) | ($000) | (000 t) | ($000) |
| **By province** | | | | |
| Newfoundland | 338 | 1,223 | 226 | 1,098 |
| Nova Scotia | 213 | 2,088 | 124 | 1,818 |
| New Brunswick | 546 | 4,565 | 546 | 5,178 |
| Quebec | 23 155 | 83,221 | 19 819 | 78,663 |
| Ontario | 27 889 | 86,620 | 21 893 | 75,284 |
| Manitoba | 863 | 2,817 | 1 922 | 7,748 |
| Alberta | 271 | 2,001 | 262 | 3,124 |
| British Columbia | 2 503 | 10,611 | 2 183 | 10,299 |
| Northwest Territories | .. | .. | 322 | 1,266 |
| Canada | 55 778 | 193,146 | 47 297 | 184,478 |
| **By use**[1] | | | | |
| Building stone | | | | |
| Rough | 293 | 1,428 | 157 | 1,360 |
| Monumental and ornamental | 1 | 72 | 1 | 51 |
| Other (flagstone, curbstone, paving blocks, etc.) | 8 | 202 | 10 | 298 |
| Chemical and metallurgical | | | | |
| Cement plants, foreign | 1 584 | 2,999 | 598 | 1,461 |
| Lining, open-hearth furnaces | 20 | 71 | 38 | 141 |
| Flux, iron and steel furnaces | 757 | 2,779 | 742 | 2,861 |
| Flux, nonferrous smelters | 151 | 1,337 | 114 | 1,124 |
| Glass factories | 188 | 2,370 | 169 | 2,272 |
| Lime kilns, foreign | 303 | 1,239 | 512 | 1,903 |
| Pulp and paper mills | 345 | 2,886 | 286 | 2,590 |
| Sugar refineries | 79 | 378 | 108 | 586 |
| Other chemical uses | 148 | 2,277 | 137 | 2,840 |
| Pulverized stone | | | | |
| Whiting substitute | 35 | 1,812 | 71 | 2,863 |
| Asphalt filler | 34 | 158 | 31 | 202 |
| Dusting, coal mines | 8 | 167 | 7 | 171 |
| Agricultural purposes and fertilizer plants | 1 020 | 9,029 | 1 018 | 10,293 |
| Other uses | 550 | 466 | 485 | 610 |
| Crushed stone for | | | | |
| Artificial stone | 30 | 123 | 1 | 37 |
| Roofing granules | 30 | 312 | 36 | 274 |
| Poultry grit | 24 | 726 | 28 | 698 |
| Stucco dash | 20 | 1,288 | 15 | 993 |
| Rock wool | 1 | 23 | - | - |
| Rubble and riprap | 471 | 1,447 | 795 | 2,350 |
| Concrete aggregate | 6 038 | 21,008 | 4 226 | 15,162 |
| Asphalt aggregate | 3 561 | 12,795 | 3 439 | 12,416 |
| Road metal | 18 108 | 58,906 | 14 953 | 50,454 |
| Railroad ballast | 999 | 3,192 | 1 124 | 3,759 |
| Other uses | 20 972 | 63,656 | 18 196 | 63,399 |
| Total | 55 778 | 193,146 | 47 297 | 181,168 |

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[1] The 1982 value of production includes companies' transportation costs not applicable in the by use category.

- Nil; .. Not available.

TABLE 3. CANADA, PRODUCTION OF MARBLE, 1981 AND 1982

| | 1981 | | 1982 | |
|---|---|---|---|---|
| | (000 t) | ($000) | (000 t) | ($000) |
| **By province** | | | | |
| Quebec | 310 | 1,881 | 332 | 2,189 |
| Ontario | 4 | 135 | 153 | 1,028 |
| Canada | 314 | 2,016 | 485 | 3,217 |
| | | | | |
| **By use**[1] | | | | |
| Building stone | | | | |
| Rough | 2 | 111 | - | - |
| Chemical process stone | | | | |
| Flux in nonferrous smelters | -- | 1 | -- | 1 |
| Pulp and paper mills | 8 | 105 | 8 | 114 |
| Pulverized stone | | | | |
| Agricultural purposes and fertilizer plants | 11 | 162 | 18 | 269 |
| Other uses | 46 | 507 | 202 | 1,543 |
| Crushed stone for | | | | |
| Artificial stone | 7 | 117 | 6 | 117 |
| Roofing granules | 2 | 50 | 1 | 32 |
| Poultry grit | -- | 1 | -- | 1 |
| Stucco dash | -- | 3 | - | - |
| Terrazzo chips | 2 | 51 | 4 | 184 |
| Concrete aggregate | 31 | 184 | 30 | 176 |
| Road metal | 51 | 172 | 125 | 400 |
| Other uses | 153 | 552 | 91 | 363 |
| Total | 314 | 2,016 | 485 | 3,200 |

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[1] The 1982 value of production includes companies' transportation costs not applicable in the by use category.
- Nil; -- Amount too small to be expressed.

## TABLE 4. CANADA, PRODUCTION OF GRANITE, 1981 AND 1982

| | 1981 | | 1982 | |
|---|---|---|---|---|
| | (000 t) | ($000) | (000 t) | ($000) |
| **By province** | | | | |
| Newfoundland | 71 | 369 | 51 | 304 |
| Nova Scotia | 1 | 21 | -- | 42 |
| New Brunswick | 1 967 | 5,773 | 1 536 | 6,001 |
| Quebec | 19 784 | 62,314 | 3 815 | 20,735 |
| Ontario | 2 666 | 29,850 | 1 480 | 23,688 |
| Manitoba | 982 | 7,035 | 423 | 3,922 |
| Alberta | - | - | 1 | 10 |
| British Columbia | 2 541 | 10,056 | 2 127 | 11,607 |
| Northwest Territories | .. | .. | -- | 1 |
| Canada | 28 012 | 115,418 | 9 434 | 66,310 |
| **By use**[1] | | | | |
| Building stone | | | | |
| Rough | 59 | 3,584 | 27 | 2,652 |
| Monumental and ornamental | 26 | 3,131 | 37 | 3,952 |
| Other (flagstone, curbstone, paving blocks, etc.) | 13 | 573 | 6 | 415 |
| Pulverized stone | | | | |
| Asphalt filler | 7 | 18 | 11 | 37 |
| Crushed stone for | | | | |
| Roofing granules | 234 | 15,569 | 215 | 16,471 |
| Poultry grit | -- | 18 | 1 | 22 |
| Rubble and riprap | 10 734 | 24,151 | 897 | 4,001 |
| Concrete aggregate | 479 | 2,183 | 280 | 1,453 |
| Asphalt aggregate | 844 | 3,329 | 898 | 4,498 |
| Road metal | 2 729 | 8,918 | 2 485 | 10,438 |
| Railroad ballast | 4 482 | 26,412 | 1 486 | 8,949 |
| Other uses | 8 405 | 27,532 | 3 091 | 12,779 |
| Total | 28 012 | 115,418 | 9 434 | 65,667 |

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[1] The 1982 value of production includes companies' transportation costs not applicable in the by use category.
- Nil; -- Amount too small to be expressed; .. Not available.

## TABLE 5. CANADA, PRODUCTION OF SANDSTONE, 1981 AND 1982

| | 1981 | | 1982 | |
|---|---|---|---|---|
| | (000 t) | ($000) | (000 t) | ($000) |
| **By province** | | | | |
| Newfoundland | 109 | 482 | 80 | 361 |
| Nova Scotia | 612 | 2,136 | 554 | 2,778 |
| New Brunswick | 174 | 326 | 179 | 376 |
| Quebec | 1 276 | 6,132 | 840 | 4,508 |
| Ontario | 4 | 234 | 32 | 259 |
| Alberta | -- | 16 | -- | 28 |
| British Columbia | - | - | -- | 20 |
| Canada | 2 176 | 9,326 | 1 686 | 8,330 |
| **By use[1]** | | | | |
| Building stone | | | | |
| Rough | 22 | 924 | 46 | 816 |
| Monumental and ornamental | -- | 4 | - | - |
| Other (flagstone, curbstone, paving blocks, etc.) | 12 | 359 | 10 | 313 |
| Crushed stone for | | | | |
| Rubble and riprap | 70 | 164 | 37 | 69 |
| Concrete aggregate | 190 | 955 | 135 | 780 |
| Asphalt aggregate | 145 | 637 | 203 | 852 |
| Road metal | 503 | 1,932 | 235 | 964 |
| Railroad ballast | 46 | 341 | 16 | 114 |
| Other uses | 1 188 | 4,010 | 1 004 | 3,659 |
| Total | 2 176 | 9,326 | 1 686 | 7,567 |

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[1] The 1982 value of production includes companies' transportation costs not applicable in the by use category.
- Nil; -- Amount too small to be expressed.

## TABLE 6. CANADA, PRODUCTION OF SHALE, 1981 AND 1982

| | 1981 | | 1982 | |
|---|---|---|---|---|
| | (000 t) | ($000) | (000 t) | ($000) |
| **By province** | | | | |
| Quebec | 436 | 1,048 | 254 | 894 |
| Ontario | 144 | 92 | 25 | 19 |
| Northwest Territories | - | - | -- | 1 |
| Canada | 580 | 1,140 | 279 | 914 |
| **By use[1]** | | | | |
| Crushed stone for | | | | |
| Rubble and riprap | - | - | 1 | 1 |
| Road metal | 358 | 893 | 200 | 539 |
| Other uses | 222 | 247 | 78 | 119 |
| Total | 580 | 1,140 | 279 | 659 |

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[1] The 1982 value of production includes companies' transportation costs not applicable in the by use category.
- Nil, -- Amount too small to be expressed.

## TABLE 7. CANADA, PRODUCTION OF STONE BY TYPES, 1975, 1980-82

| | 1975 | | 1980 | | 1981 | | 1982 | |
|---|---|---|---|---|---|---|---|---|
| | (000 t) | ($000) | (000 t) | ($000) | (000 t) | ($000) | (000 t) | ($000) |
| Granite | 11 470 | 34,913 | 39 983 | 140,914 | 28 012 | 115,418 | 9 434 | 66,310 |
| Limestone | 72 284 | 152,521 | 58 191 | 185,085 | 55 778 | 193,146 | 47 297 | 184,478 |
| Marble | 356 | 1,843 | 316 | 1,807 | 314 | 2,016 | 485 | 3,217 |
| Sandstone | 3 753 | 10,881 | 3 064 | 11,540 | 2 176 | 9,326 | 1 686 | 8,330 |
| Shale | 1 551 | 2,566 | 1 812 | 1,810 | 580 | 1,140 | 279 | 914 |
| Total | 89 414 | 202,724 | 103 366 | 341,156 | 86 860 | 321,046 | 59 181 | 263,249 |

Sources: Energy, Mines and Resources Canada; Statistics Canada.

## TABLE 8. CANADA, STONE EXPORTS AND IMPORTS, 1981-83

| | 1981 | | 1982 | | 1983P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Exports** | | | | | | |
| Building stone, rough | 11 183$^{r}$ | 1,222 | 2 942 | 576 | 12 633 | 1,877 |
| Stone crude, nes | 116 782 | 1,693 | 16 170 | 559 | 45 779 | 707 |
| Natural stone, basic products | .. | 10,359 | .. | 19,603 | .. | 22,987 |
| Total | .. | 13,274 | .. | 20,738 | .. | 25,571 |
| **Imports** | | | | | | |
| Building stone, rough | 11 086 | 1,010$^{r}$ | 11 862 | 890 | 8 049 | 1,177 |
| Stone crude, nes | 7 233 | 952 | 4 180 | 470 | 3 263 | 353 |
| Granite, rough | 34 278 | 4,802 | 22 033 | 4,095 | 24 760 | 4,447 |
| Marble, rough | 7 485 | 3,053 | 7 058 | 3,282 | 8 251 | 3,375 |
| Shaped or dressed granite | .. | 3,880 | .. | 14,831 | .. | 6,952 |
| Shaped or dressed marble | .. | 2,119 | .. | 1,709 | .. | 2,445 |
| Natural stone basic products | .. | 3,590 | .. | 3,576 | .. | 4,328 |
| Total | .. | 19,406$^{r}$ | .. | 28,853 | .. | 23,077 |

Source: Statistics Canada.
P Preliminary; nes not elsewhere specified; .. Not available; $^{r}$ Revised.

TABLE 9. CANADA, VALUE OF CONSTRUCTION[1] BY PROVINCE, 1982-84

| | 1982 | | | 1983 | | | 1984 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Building Construction | Engineering Construction | Total | Building Construction | Engineering Construction | Total | Building Construction | Engineering Construction | Total |
| | | | | | ($000) | | | | |
| Newfoundland | 414,429 | 750,073 | 1,164,502 | 496,177 | 920,309 | 1,416,486 | 529,042 | 904,131 | 1,433,173 |
| Nova Scotia | 681,430 | 884,462 | 1,565,892 | 850,097 | 1,113,145 | 1,963,242 | 935,167 | 1,263,679 | 2,198,846 |
| New Brunswick | 619,611 | 462,089 | 1,081,700 | 749,843 | 414,249 | 1,164,092 | 866,945 | 503,785 | 1,370,730 |
| Prince Edward Island | 86,981 | 72,006 | 158,987 | 106,406 | 70,694 | 177,100 | 117,272 | 79,046 | 196,318 |
| Quebec | 5,547,556 | 4,672,040 | 10,219,596 | 6,693,708 | 4,388,346 | 11,082,054 | 7,183,496 | 4,352,134 | 11,535,630 |
| Ontario | 8,897,137 | 5,510,574 | 14,407,711 | 10,015,802 | 4,819,861 | 14,835,663 | 10,498,275 | 5,031,231 | 15,529,506 |
| Manitoba | 764,362 | 657,850 | 1,422,212 | 986,418 | 656,087 | 1,642,505 | 1,083,361 | 698,296 | 1,781,657 |
| Saskatchewan | 1,165,189 | 1,343,933 | 2,509,122 | 1,451,012 | 1,413,370 | 2,864,382 | 1,410,011 | 1,515,541 | 2,925,552 |
| Alberta | 6,053,165 | 8,349,406 | 14,402,571 | 4,761,621 | 7,044,529 | 11,806,150 | 3,920,440 | 7,281,719 | 11,202,159 |
| British Columbia Yukon and Northwest Territories | 4,613,640 | 4,519,456 | 9,133,096 | 4,488,816 | 4,657,297 | 9,146,113 | 4,574,138 | 4,223,386 | 8,797,524 |
| Canada | 28,843,500 | 27,221,889 | 56,065,389 | 30,599,900 | 25,497,887 | 56,097,787 | 31,118,147 | 25,852,948 | 56,971,095 |

Source: Statistics Canada.

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[1] Actual expenditures 1982, preliminary actual 1983, intentions 1984.

# Sulphur

MICHEL A. BOUCHER

## SUMMARY

World consumption of sulphur increased in 1983 and 1984 after a sharp drop in the United States and a smaller decline in western Europe in 1982.

The recovery in sulphur came mainly from the phosphate fertilizer industry which accounts for slightly over half of total consumption, and from improvements in the economy of most industrial nations over the recessionary years of 1981 and 1982.

World production of sulfur continued to decline in 1983 for the third consecutive year but western world production which represents about two thirds of the total, increased substantially in 1984, mainly in North America and the Arabian Gulf.

The rise in consumption was not accompanied by a corresponding rise in production in recent years and as a result stocks of sulphur were reduced in several countries and prices rose considerably in the second half of 1984.

## CANADIAN DEVELOPMENTS

Canada's sulphur shipments in 1983 and 1984 were respectively 7.31 million t and 8.57 million t valued at $469 million and $637 million.

Exports in 1983 were 5.67 million t valued at $572 million. Preliminary estimates (based on 9 months figures) for 1984 indicate that exports increased to 6.93 million t valued at $741 million. The increase was mainly due to higher exports to the United States and to some developing countries of South America and Africa.

### Western Canada

The Alberta sulphur industry accounts for between 85 to 90 per cent of total Canadian production.

Sulphur production in Alberta peaked in 1973 at 7 million t, and has since been declining, mainly for two reasons: (i) sour gas pools have been generally replaced by sweeter gas pools; (ii) natural gas production and sales have been stagnant since 1973. Production of sulphur in Alberta however, has always exceeded Canadian sales during the 1970s, and as a result inventories have accumulated and reached a peak of 21.3 million t in 1980.

Sales have exceeded production since 1980 and inventories have been drawn down at a rate averaging 2.15 million tpy. At this rate inventories should be depleted in the late 1980s or early 1990s unless gas production in Canada increases substantially or high sulphur gas fields in southwestern Alberta are developed.

There were three additions to sulphur recovery capacity in Alberta during 1983. The Shell Canada Resources Limited sour gas plant at Jumping Pound, which was the first sour gas plant in Canada to recover sulphur when it went into operation in 1952, was expanded to 570 tpd from 510 tpd sulphur; Gulf Canada Resources Inc.'s 1 147 tpd sulphur plant on the Hanlan Robb reservoir came on-stream in March; Chieftain Development Co. Ltd. and Texaco Canada Resources Ltd. brought their 200 tpd sulphur plant at Hythe to the operational stage.

Procor Limited constructed a 500 tpd sulphur granulation facility at the Amoco Canada Petroleum Company Ltd. plant at East Crossfield during the year.

Shell Canada Limited closed its oil refinery and sulphur plant at Oakville, Ontario, during the summer of 1983, while a sulphur recovery unit at the adjacent Petro-Canada refinery was commissioned.

In early 1984, the Alberta Energy Resources Conservation Board gave approval

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to Shell Canada Resources Ltd. for the construction of a pipeline to move sour gas from its Moose Mountain/Whiskey Creek fields to Esso Resources Canada Ltd.'s gas processing facility at Quirk Creek. Initial deliveries of sour gas to Quirk Creek, on completion of the pipeline in 1985, are expected to result in the recovery of 40 000 tpy of sulphur.

Husky Oil Co. announced the planned construction of a Canadian $3.2 billion heavy oil upgrading plant in Saskatchewan with a capacity of around 6 700 $m^3/d$. Construction is expected to begin in 1986. Plans include a 250 tpd sulphur recovery unit. Canadian Occidental Petroleum Co. received approval from the Alberta Energy Resources Conservation Board (AERCB) and the Ministry of Environment to construct a 1.7 million $m^3/d$ sour gas processing plant which will incorporate a 200 000 tpy sulphur recovery unit to be built at Mazeppa, southeast of Calgary. Production is expected to start in mid-1986.

Canterra Energy Ltd. announced the purchase of a fourteen-section block of land at the north end of the Okotoks gas field. The land is underlain with proven sour gas reserves in the Crossfield and Elkton zones, estimated to be capable of yielding 0.6 billion $m^3$ of gas and 290 000 t of saleable sulphur. Canterra recently received approval to tie production from this land into its existing Okotoks gas gathering system where a 152 000 tpy sulphur recovery unit is located. Dome Petroleum started production of its 300 tpd sulphur unit on the West Pembina field. The Petro Canada Inc. plant in the Brazeau River field is expected to come on-stream in 1985 with a sulphur production capacity of 78 tpd. The Shell Canada plant in the Progress field is also due to come on-stream in 1985 with a sulphur production capacity of 24 tpd. Western Co-operative Fertilizers Limited's sulphuric acid plant at Medicine Hat, Alberta was closed indefinitely in mid-1983.

As a resumé of these developments, some 1 400 tpd sulphur production capacity was added in 1983, another 300 tpd was added in 1984, and some 215 tpd are planned for 1985.

**Other Developments**

Several refineries remained idle including: Newfoundland's Come-by-Chance Refinery Co. Ltd.; Gulf Canada Ltd.'s Port Tupper in Nova Scotia; Texaco Canada Resources Ltd. in Calgary; and Shell Canada Resources Ltd. in Shelburn, B.C.

Allied Corporation closed its 140 000 tpy sulphuric acid plant at Valleyfield, Quebec in June 1983 while Canadian Electrolytic Zinc expanded its sulphuric acid production capacity from 210 000 to 480 000 tpy at Valleyfield, Quebec. In 1984 the Federal Government agreed to allow oil and gas companies to negotiate natural gas export prices with buyers instead of adhering to government-posted prices. It is expected that the new measure will result in lower export prices, increased sales of natural gas to the United States and as a consequence an increase in sulphur production. Aberford Resources Ltd. and Sulpak Resources Ltd. joined Cansulex in 1984.

Sales into the offshore market in Canada are handled mainly by Cansulex (an industry marketing agency representing 20 producing companies and handling about 45 per cent of Canadian offshore sales), Shell, Canadian Superior and Amoco.

Cansulex member companies are shown below:

CANSULEX LIMITED (member companies)

- Aberford Resources Ltd.
- BP Exploration Canada Ltd.
- Canadian Occidental Petroleum Ltd.
- Canadian Reserve Oil & Gas Ltd.
- Canterra Energy Ltd.
  - Aquitaine Co. of Canada Ltd.
  - CDC Oil and Gas Ltd.
  - Texasgulf Inc.
- Champlin Canada Ltd.
- Chevron Canada Resources Limited
- Dome Petroleum Ltd.
- Gulf Canada Resources Inc.
- Hamilton Brothers Canadian Gas Co. Ltd.
- Home Oil Co. Ltd.
- Hudson's Bay Oil and Gas Co. Ltd.
- Husky Oil Canada, Ltd.
- Interedec (USA) Inc.
- Mobil Oil Canada, Ltd.
- Norcen Energy Resources Ltd.
- The Paddon Hughes Development Co. Ltd.
- Petrogas Processing Ltd.
- Sulfak Resources Ltd.
- Union Oil Co. of Canada Ltd.

Source: CANSULEX

**WORLD DEVELOPMENTS**

In the United States the Frasch mines operating at about 50 per cent of capacity in

1983 and one mine, at Comanche Creek, closed at the end of November. This followed the three Frasch operations that closed in 1982 as a result of rising costs and insufficient prices. In early 1984 the Caillou Island mine owned by Freeport was closed leaving only four Frasch mines in the United States. However in view of strong demand for sulphur Frasch production was reported to have increased substantially in 1984 from their 1983 low level of 3.2 million, but stocks continued to be depleted. Chevron Canada Limited opened a 34 km molten sulphur pipeline to a railhead from its new gas plant in the Overthrust region of Wyoming.

Saudi Arabian sulphur had the greatest impact on world markets in 1983 as most of the 1.4 million t of sulphur stockpiled before 1982 was put on the market. Sales at 1.5 million t were about double the 1982 level.

The U.S.S.R. reportedly increased fertilizer production by about 10 per cent in 1983 and relied on Poland and Canada to supply additional sulphur. The contract for construction of sulphur recovery units at the Astrakhan gas field was awarded to France's Technip. The recovery units will have a combined capacity of about 3.0 million tpy. The plant, to be completed in 1986, will process gas containing an average 24 per cent $H_2S$.

In Poland, the Oziek mine planned for development in the lat 1980s could add 1.2 million tpy of sulphur.

Polish exports to western countries increased in 1983, mainly as a result of increased imports by Brazil and Tunisia.

In November 1983, a 2 528 000 tpy sulphur recovery plant was brought on-stream at Kirkak for Iraq National Oil Co. Ltd. Production in 1984 was reported to have been only 70 000 t.

In 1984, Azufrera Panamericana SA, Mexico's state-owned sulphur producer, brought on-stream a new Frasch sulphur mine at Petapa, some 30 km west of the port of Coatzacoalas where all sulphur export facilities are located. The mine has a production capacity of 1 000 tpd. By mid-1985, Azufrera plans to open another mine at Otapa with a production capacity of 1 500 tpd. Most of the production at these mines is expected to be consumed internally by Fertimex, the state-owned fertilizer company.

Two 260 tpd sulphur recovery units came on-stream in June 1984 at Mina-al-Ahmadi in Kuwait. In 1987, a 1 000 tpd recovery unit is also expected to come on-stream at the Mina Abdulla refinery.

In Saudi Arabia the Shell/Petromin plant at Inbail on the Persian Gulf is due to come on-stream in early 1985 and produce some 80 000 tpy of sulphur.

Also, the Mobil refinery at Yanbu on the Red Sea is expected to recover 80 000 tpy to 100 000 tpy of sulphur which will be prilled and exported to Jordan. The Petrola refinery at Rabigh is expected to produce 100 000 tpy of sulphur by 1986.

In Iran a gas refinery at the Khangiran gas field near Sarakhs is planned for completion in 1986. The refinery will be able to recover 485 000 tpy sulphur.

## PRICES

Contract prices for offshore exports of elemental sulphur fob Vancouver were $Cdn. 118 for the first half of 1983 and down to $104 for the second half of the year.

In 1984 prices increased to $110 for the first half and to $140 for the second half of the year. The major reasons for the sharp increase in the second half of 1984 were as follows: Canadian, Mexican and Polish production were all sold out in early 1984; Canada was the only country in a position to respond to increased demand by remelting sulphur from its stockpile, which commands a premium; remaining inventories of Saudi Arabia were all committed; the war between Iran and Iraq caused disruptions in exports; and increased demand for sulphur particularly in the United States.

Within North America the contract price of sulphur in 1983 varied between $59-62 a t fob Alberta plant. In 1984 price increased steadily and reached $72.00 a t at year-end.

## USES

Sulphur, principally in the form of sulphuric acid, is used at some stage in the production of virtually everything we eat, wear or use. As such, its consumption level traditionally has served as an indicator of the state of the economy of an individual nation or of the world. Close to 60 per cent of all sulphur is consumed in the production of phosphate and ammonium sulphate fertilizers.

## OUTLOOK

### Short-term

The tight supply-demand situation that existed in the sulphur industry in 1984 is expected to continue in 1985 because world consumption should again exceed production as no new major producer is expected to come on-stream. As a result sulphur inventories in Canada should continue to decline.

Prices will likely remain high in 1985. It was reported, however, that in 1984 many fertilizer producers which require approximately half a tonne of sulphur to produce one tonne of ammonium phosphate fertilizer were barely breaking even.

### Long-term

On the supply side the major development in the world will be the Astrakhan project in the U.S.S.R. which should add some 6 million tpy of sulphur during the period 1987-1992; most of the new production however is expected to "eventually" be consumed internally.

New projects in the western world such as in Mexico, Saudi Arabia, Kuwait, Iran and Poland will not add significantly to production because they will replace mines that are being depleted in Poland (Grzybow Frasch mine), France (Lacq gas field), and Mexico (Joltipan Frasch mine) among others. In the United States only minor increases in production are forecasted to 1990.

Natural gas price deregulations in Canada are expected to result in increased production and sales of gas to the United States, and consequently higher sulphur production.

Recovery of sulphur from smelters and power plants in North America and western Europe may add 1 to 3 million t to production by the end of the decade.

On the consumption side growth is expected to outpace production for the next three to four years. Strong growth is expected mainly in Asia (China, Israel, Iraq), Africa (Morocco, Tunisia), South America (Brazil), and eastern Europe (U.S.S.R., Yugoslavia).

The imbalance in production and consumption should result in: a reduction of inventories mainly in Canada but also in other producing countries; higher prices; a displacement of shipments to export markets where prices are higher; and increased production from voluntary (Frasch, native and pyrite mines) producers.

**PRICES**

| | 1982 | 1983 |
|---|---|---|
| | ($/tonne) | |
| Canadian sulphur prices as quoted in Alberta Energy Resources Industries monthly statistics | | |
| Sulphur elemental, fob plant | | |
| North American deliveries | 64.36 | 52.64 |
| Offshore deliveries | 80.44 | 61.43 |
| Canadian sulphuric acid price as quoted in Corpus Chemical Report | | |
| Sulphuric acid, fob plants, East, 66° Be, tanks | 98.80 | 104.0 |
| United States prices, U.S. currency, as quoted in Engineering and Mining Journal | | |
| Sulphur elemental | | |
| U.S. producers, term contracts fob vessel at Gulf ports, Louisiana and Texas | | |
| Bright | 137.8 | 130.4 |
| Dark | 137.8 | 131.4 |
| Export prices, ex terminal Holland | | |
| Bright | 143.7-150.0 | 130.9-137.8 |
| Dark | 143.7-150.0 | 130.9-137.8 |
| Mexican export, fob vessel, U.S. currency, from Azufrera Panamericanna S.A. | | |
| Bright | 108.2-113.1 | .. |
| Dark | 123.0-132.8 | .. |

fob Free on board; .. Not available.

**TARIFFS**

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| CANADA | | | | | |
| 92503-1 | Sulphur of all kinds, other than sublimed sulphur, precipitated sulphur and colloidal sulphur | free | free | free | free |
| 92802-1 | Sulphur, sublimed or precipitated; colloidal sulphur | free | free | free | free |
| 92807-1 | Sulphur dioxide | free | free | free | free |
| 92808-1 | Sulphuric acid, oleum | 9.4 | 7.5 | 25 | 5 |
| 92813-4 | Sulphur trioxide | free | free | free | free |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 92808-1 | 7.5 | 5.6 | 3.8 | 1.9 | free |

UNITED STATES

| | | |
|---|---|---|
| 418.90 | Pyrites | free |
| 415.45 | Sulphur, elemental | free |
| 416.35 | Sulphuric acid | free |

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 422.94 | Sulphur dioxide | 5.1 | 4.9 | 4.7 | 4.4 | 4.2 |

Sources: The Customs Tariff, 1983 Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1983), USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, SULPHUR SHIPMENTS AND TRADE, 1982-84

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Shipments** | | | | | | |
| Pyrite and pyrrhotite[1] | | | | | | |
| Gross weight | 20 000 | .. | - | - | - | - |
| Sulphur content | 9 000 | 220 | - | - | - | - |
| Sulphur in smelter gases[2] | 627 000 | 42,027 | 678 286 | 42,322 | 874 906 | 63,300 |
| Elemental sulphur[3] | 6 945 000 | 569,928 | 6 631 123 | 427,358 | 7 700 455 | 574,177 |
| Total sulphur content | 7 581 000 | 612,175 | 7 309 409 | 469,680 | 8 575 361 | 637,477 |
| **Imports** | | | | | | |
| Sulphur, crude or refined | | | | | Jan.-Sept. 1984 | |
| United States | 2 159 | 395 | 2 353 | 653 | 2 341 | 639 |
| Other countries | - | - | 12 | 3 | 4 | 1 |
| Total | 2 159 | 395 | 2 365 | 656 | 2 345 | 640 |
| Sulphuric acid, including oleum | | | | | | |
| United States | 74 262 | 4,847 | 116 567 | 8,353 | 22 768 | 2,122 |
| West Germany | 74 405 | 2,480 | 7 484 | 248 | 3 | - |
| Norway | 22 390 | 913 | 2 522 | 172 | - | - |
| Other countries | 21 457 | 840 | - | - | 10 | 10 |
| Total | 192 514 | 9,080 | 126 573 | 8,952 | 22 781 | 2,132 |
| **Exports** | | | | | | |
| Sulphur in ores (pyrite) | | | | | (Jan.-Sept. 1984) | |
| West Germany | - | - | .. | 63 | - | - |
| United States | .. | 239 | .. | 14 | .. | 34 |
| Japan | - | 429 | - | - | - | - |
| Total | .. | 668 | .. | 77 | .. | 34 |
| Sulphuric acid, including oleum | | | | | | |
| United States | 259 716 | 8,404 | 250 061 | 7,744 | - | - |
| Other countries | 24 | 20 | 11 | 3 | 22 984[4] | 892 |
| Total | 259 740 | 8,424 | 250 612 | 7,747 | 22 984 | 892 |
| Sulphur, crude or refined, nes | | | | | | |
| United States | 1 132 352 | 85,510 | 1 112 860 | 76,797 | 1 270 171 | 93,204 |
| Brazil | 447 439 | 60,621 | 573 145 | 66,071 | 323 855 | 40,797 |
| Morocco | 464 889 | 61,544 | 358 735 | 40,153 | 270 455 | 33,689 |
| Tunisia | 349 830 | 45,432 | 310 095 | 38,261 | 227 173 | 30,133 |
| South Africa | 453 336 | 59,748 | 366 640 | 38,079 | 394 812 | 44,322 |
| Australia | 467 268 | 58,234 | 364 448 | 37,878 | 327 473 | 37,781 |
| South Korea | 194 236 | 26,058 | 296 146 | 33,168 | 258 830 | 30,661 |
| People's Republic of China | 309 906 | 41,449 | 217 027 | 24,183 | 189 651 | 20,841 |
| U.S.S.R. | 201 086 | 27,628 | 198 075 | 21,890 | 136 800 | 15,596 |
| Finland | 96 758 | 13,303 | 179 732 | 21,880 | 124 572 | 14,254 |
| India | 373 239 | 43,172 | 218 170 | 18,298 | 150 185 | 18,783 |
| Israel | 152 773 | 10,802 | 226 517 | 18,092 | 192 462 | 18,211 |
| Taiwan | 125 922 | 17,638 | 152 825 | 16,248 | 140 741 | 15,949 |
| Netherlands | 53 603 | 7,223 | 149 151 | 15,672 | 142 787 | 15,543 |
| France | 51 029 | 7,022 | 122 754 | 15,167 | 71 561 | 8,577 |
| New Zealand | 208 410 | 25,864 | 158 021 | 15,114 | 163 291 | 19,500 |
| Other countries[5] | 1 029 368 | 128,581 | 665 934 | 75,329 | 816 384 | 98,104 |
| Total | 6 111 444 | 719,829 | 5 670 275 | 572,280 | 5 201 203 | 556,021 |

Source: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments of byproduct pyrite and pyrrhotite from the processing of metallic sulphide ores. [2] Sulphur in liquid $SO_2$ and $H_2SO_4$ recovered from the smelting of metallic sulphides and from the roasting of zinc-sulphide concentrates. [3] Producers' shipments of elemental sulphur produced from natural gas; also included are small quantities of sulphur produced in the refining of domestic crude oil and synthetic crude oil. [4] Netherlands and Switzerland. [5] Mainly Belgium-Luxembourg, Senegal, Indonesia, Argentina, Chile, Cuba, and Mozambique.

P Preliminary; - Nil; .. Not available; nes Not elsewhere specified.

## TABLE 2. CANADA, SOUR GAS SULPHUR EXTRACTION PLANTS, 1982 AND 1983

| Operating Company | Source Field or Plant Location | $H_2S$ in Raw Gas | 1982 Daily Sulphur Capacity | 1983 Daily Sulphur Capacity |
|---|---|---|---|---|
| | (Alberta, except where noted) | (%) | (tonnes) | (tonnes) |
| Amerada Hess Corporation | Olds | 13 | 384 | 389 |
| Amoco Canada Petroleum | Bigstone Creek | 19 | 382 | 382 |
| Amoco Canada Petroleum | East Crossfield | 26 | 1 757 | 1 797 |
| Canada-Cities Service, Ltd. | Paddle River | 1 | 19 | 19 |
| Canadian Superior Oil Ltd. | Harmattan-Elkton | 56 | 490 | 490 |
| Canadian Superior Oil Ltd. | Lonepine Creek | 12 | 157 | 157 |
| Sulpetro Limited | Minnehik-Buck Lake | 1 | 45 | 45 |
| Canterra Energy Ltd. | Brazeau River | 2 | 42 | 42 |
| Canterra Energy Ltd. | Okotoks | 34 | 459 | 431 |
| Canterra Energy Ltd. | Rainbow Lake | 4 | 139 | 139 |
| Canterra Energy Ltd. | Ram River (Ricinus) | 19 | 4 567 | 4 572 |
| Canterra Energy Ltd. | Windfall | 8 | | |
| Chevron Standard Limited | Kaybob South | 20 | 3 521 | 3 537 |
| Chevron Standard Limited | Nevis | 7 | 260 | 215 |
| Chieftain | Sinclair | 5 | | 256 |
| Dome Petroleum Limited | Steelman, Sask. | 1 | 7 | 7 |
| Esso Resources Canada | Joffre | 11 | 17 | 17 |
| Esso Resources Canada | Quirk Creek | 4 | 300 | 293 |
| Esso Resources Canada | Redwater | 4 | 33 | 33 |
| Gulf Canada Limited | Homeglen-Rimbey | 2 | 333 | 333 |
| Gulf Canada Limited | Nevis | 7 | 295 | 297 |
| Gulf Canada Limited | Pincher Creek | 5 | 160 | 159 |
| Gulf Canada Limited | Strachan | 9 | 943 | 943 |
| Gulf Canada Limited | Hanlan | 9 | | 1 092 |
| Home Oil Company Limited | Carstairs | 1 | 72 | 65 |
| Hudson's Bay Oil and Gas | Brazeau River | 1 | 110 | 110 |
| Hudson's Bay Oil and Gas | Caroline | 1 | 22 | 8 |
| Hudson's Bay Oil and Gas | Edson | 2 | 284.5 | 284 |
| Hudson's Bay Oil and Gas | Kaybob South (1) | 13 | 1 064 | 1 086 |
| Hudson's Bay Oil and Gas | Kaybob South (2) | 17 | 1 064 | 1 085 |
| Hudson's Bay Oil and Gas | Lonepine Creek | 10 | 283 | 283 |
| Hudson's Bay Oil and Gas | Sturgeon Lake | 12 | 49 | 96 |
| Hudson's Bay Oil and Gas | Zama | 8 | 74 | 74 |
| Mobil Oil Canada, Ltd. | Wimborne | 14 | 168 | 182 |
| Mobil Oil Canada, Ltd. | Teepee | 4 | 29 | 30 |
| PanCanadian Petroleum Limited | Morley | 5 | 18 | 18 |
| Petro-Canada | Gold Creek | 5 | 43 | 43 |
| Petro-Canada | Wildcat Hills | 4 | 177 | 177 |
| Petrogas Processing Ltd. | Crossfield (Balzac) | 14 | 1 687 | 1 696 |
| Saratoga Processing Company | Savannah Creek (Coleman) | 20 | 389 | 389 |
| Shell Canada Limited | Burnt Timber Creek | 10 | 497 | 489 |
| Shell Canada Limited | Innisfail | 23 | 163 | 163 |
| Shell Canada Limited | Jumping Pound | 6 | 511 | 566 |
| Shell Canada Limited | Rosevear | 8 | 153 | 171 |
| Shell Canada Limited | Simonette River | 7 | 267 | 95 |
| Shell Canada Limited | Waterton | 17 | 3 066 | 3 107 |
| Suncor Inc. | Rosevear | 8 | 110 | 110 |
| Texaco Exploration Company | Bonnie Glen | - | 15 | 12.5 |
| Voyager | Mundare | | | |
| Westcoast Transmission | Fort Nelson, B.C. | | 1 100 | 1 100 |
| Westcoast Transmission | Taylor Flats, B.C. | 3 | 460 | 460 |
| Westcoast Transmission | Pine River | | 1 055 | |
| Western Decalta Petroleum | Turner Valley | 1 | 24 | 11 |
| Total daily rated capacity December 31, 1982 - 1983. | | | | 28 439 |

Sources: From Alberta Energy Resources Conservation Board publications.
- Nil

**TABLE 3. CANADIAN REFINERY SULPHUR CAPACITIES, 1982 AND 1983**

| Operating Company | Location | 1982 | 1983 |
|---|---|---|---|
| | | Daily Capacity (tonnes) | |
| Gulf Canada Limited | Edmonton, Alberta | 103 | 56 |
| | Port Moody, B.C. | 25 | 25 |
| | Clarkson, Ontario | 40 | 49 |
| | Port Tupper, N.S. | (40) | ( ) |
| Husky Oil Ltd. | Prince George, B.C. | 5 | 5 |
| Imperial Oil Ltd. | Edmonton, Alberta | 36 | 40 |
| | Dartmouth, N.S. | 40 | 76 |
| | Sarnia, Ontario | 103 | 100 |
| | Vancouver, B.C. | 20 | 20 |
| Irving Oil Ltd. | Saint John, N.B. | 200 | 200 |
| Sulconam Inc. | Montreal, Quebec | 300 | 300 |
| Petro-Canada | Oakville, Ontario | | 41 |
| Newfoundland Refining Co. Ltd. | Come-by-Chance, Nfld. | (194) | ( ) |
| Shell Canada Res. Ltd. | Shellburn, B.C. | 15 | ( ) |
| | Oakville, Ontario | 35 | ( ) |
| | Sarnia, Ontario | 31 | 31 |
| Suncor Inc. | Sarnia, Ontario | 10 | 10 |
| Texaco Canada Res. Ltd. | Nanticoke, Ontario | 8 | 8 |
| | Calgary, Alta. | 10 | ( ) |
| Canadian Ultramar Limited | Montreal, Quebec | 81 | 81 |
| Total | | 1 062 | 942 |

Sources: Oilweek, April 16, 1984 Chemical Economics Handbook.
( ) Not operational

## TABLE 4. CANADA, PRINCIPAL SULPHUR DIOXIDE AND SULPHURIC ACID PRODUCTION CAPACITIES, 1983[1]

| Operating Company | Plant Location | Raw Material | Annual Capacity Sulphuric Acid[2] | |
|---|---|---|---|---|
| | | | Sulphuric Acid[2] | S. equiv. |
| | | | (000 tonnes) | |
| Allied Corporation[3] | Valleyfield, Que. | $SO_2$ zinc conc. | 127 | 42 |
| Brunswick Mining and Smelting Corporation Limited | Belledune, N.B. | $SO_2$ lead-zinc | 160 | 52 |
| Canadian Electrolytic Zinc Ltd.[4] | Valleyfield, Que. | $SO_2$ zinc conc. | 440 | 144 |
| C-I-L Inc. | Beloeil, Que. | Elem. S. | 65 | 21 |
| Inco Metals Company | Copper Cliff, Ont. | $SO_2$ pyrrhotite | 900 | 294 |
| | Copper Cliff, Ont. | $SO_2$ copper | Liquified $SO_2$ | 45 |
| NL Chem Canada Inc. | Varennes, Que. | Elem. S. | 56 | 18 |
| Falconbridge Limited | Sudbury, Ont. | $SO_2$ pyrrhotite | 355 | 116 |
| International Minerals & Chemical Corporation (Canada) Limited | Port Maitland, Ont. | Elem. S. | 250 | 82 |
| Gaspé Copper Mines, Limited | Murdochville, Que. | $SO_2$ copper | 160 | 52 |
| Canada Colors and Chemicals | Elmira, Ont. | Elem. S. | 32 | 11 |
| Kidd Creek Mines Ltd. | Kidd Creek, Ont. | $SO_2$ zinc conc. | 440[6] | 144 |
| Subtotal Eastern Canada | | | 2 985 | 1 021 |
| Border Chemical Company Ltd. | Transcona, Man. | Elem. S. | 150 | 49 |
| Cominco Ltd. | Kimberley, B.C. | $SO_2$ pyrrhotite | 300 | 98 |
| | Trail, B.C. | $SO_2$ lead-zinc | 430 | 141 |
| | Trail, B.C. | $SO_2$ lead-zinc | Liquified $SO_2$ | 40 |
| Esso Chemical Canada | Redwater, Alta. | Elem. S. | 965 | 316 |
| Eldorado Resources Limited | Rabbit Lake, Sask. | Elem. S. | 45 | 15 |
| Inland Chemicals Ltd. | Fort Saskatchewan, Alta. | Elem. S. | 136 | 44 |
| | Prince George, B.C. | Elem. S. | 35 | 11 |
| Sherritt Gordon Mines Limited | Fort Saskatchewan, Alta. | Elem. S. | 215 | 70 |
| Western Co-operative Fertilizers Limited | Calgary, Alta. | Elem. S. | 417 | 136 |
| | Medicine Hat, Alta.[5] | Elem. S. | 530 | 173 |
| Subtotal Western Canada | | | 3 223 | 1 093 |
| TOTAL | | | 6 208 | 2 114 |

Source: Company reports.
[1] 100 per cent $H_2SO_4$. [2] Plant capacities are related to process changes in 1983. [3] Allied Corporation ceased production in June 1983. [4] Canadian Electrolytic Zinc Limited expanded plant capacity in 1983. [5] Western Cooperative Fertilizers Limited closed Medicine Hat plant in April 1983. [6] Expansion to 530 000 tpy planned for mid-1987.

### TABLE 5. CANADA, SULPHUR SHIPMENTS AND TRADE, 1966, 1970, 1971, 1975, 1979-84

| | Shipments[1] | | | | Imports | Exports | |
|---|---|---|---|---|---|---|---|
| | Pyrites | In Smelter Gases | Elemental Sulphur | Total | Elemental Sulphur | Pyrites[2] | Elemental Sulphur |
| | (tonnes) | | | | (tonnes) | ($) | (tonnes) |
| 1966 | 147 226 | 453 870 | 1 851 924 | 2 453 020 | 131 955 | 981,000 | 1 269 157 |
| 1970 | 159 222 | 640 360 | 3 218 973 | 4 018 555 | 48 494 | 1,226,000 | 2 711 069 |
| 1971 | 140 642 | 561 046 | 2 856 796 | 3 558 484 | 27 923 | 1,074,000 | 2 401 975 |
| 1975 | 10 560 | 694 666 | 4 078 780 | 4 784 006 | 14 335 | 170,000 | 3 284 246 |
| 1979 | 13 964 | 667 265 | 6 314 244 | 6 995 473 | 1 699 | 281,000 | 5 154 831 |
| 1980 | 14 328 | 894 732 | 7 655 723 | 8 564 783 | 1 767 | 386,000 | 6 850 143 |
| 1981 | 5 000 | 783 000 | 8 018 000 | 8 806 000 | 4 633 | 109,000 | 7 309 216 |
| 1982 | 9 000 | 627 000 | 6 945 000 | 7 581 000 | 2 159 | 668,000 | 6 111 444 |
| 1983 | - | 678 286 | 6 631 123 | 7 309 409 | 2 365 | 77,000 | 5 670 275 |
| 1984P | - | 874 906 | 7 700 455 | 8 575 361 | | | |

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] See footnotes for Table 1. [2] Quantities of pyrites exported not available.
P Preliminary; - Nil.

### TABLE 6. CANADA, SULPHURIC ACID PRODUCTION, TRADE AND APPARENT CONSUMPTION, 1966, 1970, 1971, 1975, 1979-83P

| | Production | Imports | Exports | Apparent Consumption |
|---|---|---|---|---|
| | | (tonnes - 100% acid) | | |
| 1966 | 2 267 962 | 6 303 | 49 848 | 2 224 417 |
| 1970 | 2 475 070 | 9 948 | 129 327 | 2 355 691 |
| 1971 | 2 660 773 | 4 492 | 91 711 | 2 573 554 |
| 1975 | 2 723 202 | 154 020 | 225 402 | 2 651 820 |
| 1979 | 3 666 080 | 170 618 | 139 425 | 3 697 273 |
| 1980 | 4 295 366 | 18 048 | 323 775 | 3 989 639 |
| 1981 | 4 116 860 | 82 495 | 337 518 | 3 861 837 |
| 1982 | 3 130 854 | 192 514 | 259 740 | 3 063 628 |
| 1983P | 3 686 427 | 126 573 | 250 612 | 3 562 388 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary.

## TABLE 7. WORLD PRODUCTION OF SULPHUR IN ALL FORMS, 1982

| | Elemental | Other[1] | Total |
|---|---|---|---|
| | (000 tonnes) | | |
| United States | 8 614 | 2 094 | 10 708 |
| U.S.S.R. | 3 556 | 5 576 | 9 132 |
| Canada | 5 628 | 624 | 6 252 |
| Poland | 4 935 | 159 | 5 094 |
| Japan | 1 062 | 1 648 | 2 710 |
| Mexico | 1 900 | 85 | 1 985 |
| France | 1 819 | 150 | 1 969 |
| West Germany | 1 125 | 652 | 1 777 |
| Spain | 20 | 1 014 | 1 034 |
| Italy | 86 | 400 | 486 |
| Finland | 40 | 430 | 470 |
| Sweden | 22 | 312 | 334 |
| Iraq | 200 | - | 200 |
| Iran | 20 | - | 20 |
| Other countries | 2 456 | 6 282 | 8 738 |
| Total | 31 483 | 19 426 | 50 909 |

Source: British Sulphur Corporation Limited, Sulphur No. 170, January-February 1984.

[1] Sulphur in other forms includes sulphur contained in pyrites and contained sulphur recovered from metallurgical waste gases mostly in the form of sulphuric acid.

- Nil.

## TABLE 8. CANADIAN EXPORT MARKETS FOR SULPHUR, 1983P

| Country or Area | Exports | Per cent of Total |
|---|---|---|
| | (million tonnes) | |
| United States | 1.11 | 19.6 |
| Europe | .85 | 15.0 |
| Brazil | .57 | 10.1 |
| South Africa | .37 | 6.5 |
| Australia | .36 | 6.3 |
| Tunisia | .31 | 5.5 |
| South Korea | .30 | 5.3 |
| India | .22 | 3.9 |
| New Zealand | .16 | 2.8 |
| Taiwan | .15 | 2.6 |
| Others | 1.27 | 22.4 |
| Total | 5.67 | 100.0 |

Source: Statistics Canada.
P Preliminary.

## TABLE 9. CANADA, SULPHURIC ACID CONSUMPTION BY END USE, 1982 AND 1983

| | 1982 | 1983 |
|---|---|---|
| | (tonnes) | |
| Uranium mines | 339 294 | 300 236 |
| Miscellaneous metal mines | 44 535 | 12 111 |
| Crude petroleum and natural gas industry | 4 449 | 4 174 |
| Sugar, vegetable oil and miscellaneous food processors | 2 253 | 837 |
| Leather industries | ) 2 953 | 17 530 |
| Textile industries | ) | |
| Pulp and paper mills | 257 863 | 278 126 |
| Iron and steel mills | 7 406 | 2 720 |
| Smelting and refining | 219 675 | 211 649 |
| Electrical products industries | 17 150 | 21 653 |
| Petroleum refineries and coal products | 31 201 | 32 923 |
| Fertilizers and other industrial chemicals | 2 353 015 | 2 404 399 |
| Plastics and synthetic resins | 39 299 | 463 |
| Soap and cleaning compounds | 15 323 | 11 544 |
| Explosives and miscellaneous chemical industries | 56 527 | 38 003 |
| Miscellaneous manufacturing industries | 10 861 | 9 413 |
| Other end uses[1] | 33 146 | 31 927 |

Source: Reports from producing companies.

[1] Other end uses include miscellaneous non-metal mines; automotive; hydro, municipal utility and water; metal fabricating; and miscellaneous manufacturing industries.

# Talc, Soapstone and Pyrophyllite

M. PRUD'HOMME

## SUMMARY

Since 1982, Canadian production of talc, soapstone and pyrophyllite has risen continuously due to new installed capacities and aggressive marketing, especially in the United States. In 1984, the value of shipments of talc and pyrophyllite increased by 31 per cent, compared to 57 per cent in 1983. Imports increased slightly to 38 000 t mainly from the United States. Exports of talc to the United States increased by 71 per cent in 1983, and talc and pyrophyllite exports increased by 40 per cent in 1984.

In 1984, Canada Talc Inc. completed the construction of its new 80 000 tpy talc and dolomite plant in Marmora, Ontario. Steetley Talc Limited completed the first phase of an expansion program which will increase its production capacity to 45 000 tpy at Timmins, Ontario. Bakertalc Inc. installed new filtering facilities to improve efficiency at its plant near Highwater in Quebec. BSQ Talc Inc. conducted drilling to assess new reserves near St.-Pierre-de-Broughton in the Eastern Townships, Quebec.

Talc prices have risen by an average of 8 per cent annually since 1982. Over the short-term talc markets have maintained growth because of the versatility of talc and because of competitive prices. Markets related to the construction sector will show steady growth, depending on economic recovery. Appreciable growth is expected in the plastics and the pulp and paper industries for the next few years.

Talc is a hydrous magnesium metasilicate, $Mg_3Si_4O_{10}(OH)_2$, and is usually intimately associated with numerous other minerals such as serpentine, dolomite and quartz. The colour is characteristically a pale green, grey or creamy white. It exhibits a pearly lustre, a low hardness, a greasy feel and an extreme smoothness. Talc is derived from the alteration of magnesian rocks in an intensive metamorphic environment. It occurs as veinlets, tabular bodies or irregular lenses. Talc is valued for its various properties: extreme whiteness, smoothness, high fusion point, low thermal and electrical conductivity and chemical inertness. Talc is produced in various grades which are usually classified by end-use: paint, ceramic, pharmaceutical and cosmetic.

Steatite (soapstone) is an impure, massive, compact form of talc which can be sawn or machined easily. "Steatite grade" is a special block talc suitable for making ceramic insulators. Soapstone is a mixture of talc, serpentine, chlorite, dolomite with, sometimes, small percentages of quartz and calcite. Its durability depends on its chemical inertness and non-absorbency properties. Soapstone has been used since early times in many parts of the world for carving ornaments, pipes, cookware, lamps and other utensils. The art of carving this rock has survived among the Inuit people of Canada up to the present era. Present uses include metalworkers' crayons, refractory bricks, and blocks for sculpturing.

Pyrophyllite is a hydrous aluminum silicate, $Al_2Si_4O_{10}(OH)_2$, formed by hydrothermal alteration of acid igneous rocks, predominantly lavas which are andesitic to rhyolitic in composition. It occurs in low-and medium-grade metamorphic rocks rich in aluminum. Its physical properties are practically identical to those of talc, and, for this reason, pyrophyllite finds industrial uses similar to talc, notably in ceramic bodies and as a filler in paint, rubber and other products.

## PRODUCTION AND DEVELOPMENTS IN CANADA

**Talc, soapstone.** The earliest recorded production of talc or soapstone in Canada was in 1871-72 when 270 t of cut soapstone, valued at $1,800 was shipped from a deposit in Bolton Township, southern Quebec, by Slack and Whitney. In 1896, a deposit in Huntingdon Township, in the Madoc district

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of Ontario, was opened, and over the next few years numerous deposits were discovered in this area and mined intermittently. Several deposits in southern British Columbia and one in southwestern Alberta were discovered prior to 1920 and some were worked on a small scale.

At present, talc is produced commercially in two provinces, Quebec and Ontario, while pyrophyllite is produced only in Newfoundland.

Bakertalc Inc. produces talc and soapstone from an underground operation at South Bolton, Quebec, 95 km southeast of Montreal. Talc occurs as dykes and sills, associated with serpentine and magnesite, in Cambrian and Lower Ordovician schists. Ore is extracted at the Van Reet mine and is trucked 16 km south to the company's mill facilities at Highwater. It produces around 5 000 tpy of high quality floated material for use principally in the pulp and paper industry, and a similar tonnage of dry-milled talc used as an industrial filler in paints and plastics. Soapstone is also supplied as sculpture blocks. St. Lawrence Chemicals Inc. is the distributor for all Bakertalc's products. In 1983, Bakertalc Inc. assessed the use of talc as a substitute for asbestos in an asbestos manufactured product. Successful tests resulted in increased sales in 1983. In 1984, the company installed new filtering facilities in its mill to increase efficiency and to recover tailings from the production of high-purity talc. Current work with le Centre de Recherches Minérales (CRM) is being done to improve the flotation process and to perfect the determination of talc grades in concentrates.

BSQ Talc Inc., near St.-Pierre-de-Broughton in Quebec, quarries two deposits associated with the Pennington dyke in Leeds and Thetford townships. Occurrences are associated with ultrabasic intrusives, peridotite-serpentinite, in quartz-carbonate-chlorite schists. BSQ Talc Inc. produces ground material containing nearly 70 per cent talc, which is used as a filler in joint cement and auto-body compound and as a dusting agent in asphalt roofing shingles and rubber production. It also supplies soapstone products such as refractory slabs and sculpture blocks through its subsidiary Benmic Inc. Metalworker's crayons are produced by a new process developed by le Centre de Recherche Industrielle du Québec (CRIQ). Rated capacity of the plant is around 35 000 t. In 1984, the company did some development work, such as stripping and drilling, to assess new reserves. Expansion plans are projected to increase the quality of its talc products in the near future.

Canada Talc Inc. operates an underground talc mine and also quarries a newly-discovered talc orebody at Madoc, Ontario. The orebodies occur in crystalline dolomite, where tabular hydrothermal replacements have taken place. The talc is of exceptional whiteness and may contain accessory minerals such as sulphides, mica and prismatic tremolite.

Since 1982, Canada Talc Inc. has conducted mapping, trenching and drilling on its properties in the Queensborough Road area of Elzevir Township and in Cashel Township. In 1983, the W.R. Barnes Company Limited has been custom milling talc ore for Canada Talc at Northbrook to produce materials for the roofing and automotive body filler markets. In 1984, an $825,000 grant, from the Ontario Ministry of Natural Resources under the Small Rural Mineral Development Program, was offered in order to increase talc production at Madoc and to provide assistance for an expansion at Marmora, 17 km west of the mine site. In November 1984, the company completed its 80 000 tpy talc and dolomite processing plant at Marmora. This $3.76 million facility will produce 44-, 20- and 10-micron size talc and dolomite products for the paint, plastics and paper industries. Dolomite terrazzo chips and talcose dolomite are also produced.

Steetley Talc Limited, a division of Steetley Industries Limited, produces talc from an open-pit mine in Penhorwood Township, 70 km southwest of Timmins. Talc occurs in talc-magnesite deposits derived from the alteration of ultrabasic volcanic rocks. The ore is processed by flotation and fine-grinding. The talc is a high purity, platy material and it is used mainly in the pulp industry as a pitch control agent. Other markets are in paints, plastics, paper and cosmetics. Since 1982, R.T. Vanderbilt Co. Inc. is the distributor of their talc products in the American markets. Steetley Talc Limited is engaged in a $3.76 million multi-stage expansion program to increase production and to improve the quality of its talc products. The company received a provincial grant of $940,000 through the Board of Industrial Leadership and Development. Annual capacity of the plant is about 27 000 t with plans to increase to 33 000 t by 1985. Further development work will be carried out to recover magnesite from the magnesium-silicate deposit.

During 1984, several developments undertaken in Canada are worthy of note. Clayburn Co. at Coalmont, British Columbia, produced a small tonnage of low quality talc for use in its refractory plant. International Marble and Stone Company Limited made a trial shipment of low quality talc for application as an industrial filler from the Haas Creek deposit, west of Greenwood, British Columbia. Wabigoon Resources Limited did some bulk sampling for flotation testing to determine the quality of talc from the Wabigoon Lake soapstone-talc property in Zealand Township, Ontario. Ram Petroleum Limited completed a small mill near Clarendon in Palmerston Township, Ontario to process material from a tremolite deposit containing 10 per cent talc. An off-white material will be produced for use in asphalt and concrete applications. In Quebec, geologists of the Energy and Resources department conducted investigations of talc and steatite occurrences in the Eastern Townships; surface mapping and detailed cartography were carried out along the Pennington dyke between Thetford Mines and Black Lake.

Numerous deposits of talc and soapstone occur near the producing areas and in other parts of Canada. A soapstone deposit on Pipestone Lake in Saskatchewan was worked by Indians for the manufacture of pipes and various utensils. Reserves are reported to be considerable. High quality "blue" talc was investigated in the Banff area of Alberta and British Columbia during the 1930s. In the Northwest Territories, a few occurrences of soapstone are known from which Eskimos obtained material for carving. Showings of minor importance occur at several localities in Nova Scotia, Newfoundland and eastern Ontario.

**Pyrophyllite.** Newfoundland Minerals Limited, a subsidiary of American Olean Tile Company, Inc. (a division of National Gypsum Company), mines pyrophyllite from an open-pit operation near Manuels, 19 km southwest of St. John's, Newfoundland. The deposit appears to be a hydrothermal alteration of sheared rhyolite. Altered zones are associated mainly with extensive fracturing near intrusive granite contacts. Reserves are believed to be sufficient for about 40 years at the present production rate. The mine has operated continuously since 1955. Ore is crushed, sized and hand-cobbed at the mine site prior to being trucked a short distance to tidewater. Annual production varies between 30 000 and 45 000 t. The cut-off grade is 17 per cent aluminum oxide. High-quality crude ore is shipped to the parent company's ceramics plants at Lansdale, Pennsylvania, and Jackson, Mississippi. Some lower grade pyrophyllite has been used in the local manufacture of joint cement, stucco, paints and other products, since 1975.

Other known pyrophyllite deposits in Canada include an extensive area of impure pyrophyllite near Stroud's Pond in the southern part of Burin Peninsula, Newfoundland; occurrences near Senneterre in Abitibi County, Quebec and deposits in British Columbia, near Ashcroft and on Vancouver Island.

## TRADE AND MARKETS

Since 1982 the value of shipments of talc and pyrophyllite has risen steadily, by 57 per cent in 1983 and 31 per cent in 1984. The value of pyrophyllite represents 10-13 per cent of the total value of talc minerals. In 1984, the increased value reflects record levels of production and a greater tonnage of high purity talc products.

In 1983, the value of imports increased by 11 per cent while tonnage increased by 3 per cent, compared to 1982. For 1984, imports are expected to increase slightly, near 38 500 t. The average value of imports was $175 per t in 1983, compared to $163 per t in 1982; an increase of 7 per cent in current dollars which is marginal taking into account the inflation effect and the currency exchange rate, as 98 per cent of our imports are from the United States. High quality talc is imported mainly into Ontario (45 per cent), British Columbia (23 per cent), Quebec (18 per cent) and Alberta (10 per cent). Exports to the United States, which account for 99 per cent of total exports, increased by 71 per cent in 1983. For 1984, exports are expected to increase by nearly 40 per cent due to higher shipments of pyrophyllite and the fact that Canadian talc producers captured a greater share of markets in the United States, especially in the northeastern areas.

Since 1982, apparent consumption of talc has increased annually by an average of 10 per cent. In 1983, end-use of ground talc was as follows: roofing products, 19 per cent; paints, 18 per cent; paper, 18 per cent; gypsum products and putty compounds, 17 per cent; rubber and plastics, 9 per cent; ceramics, 9 per cent; chemicals and pharmaceuticals, 5 per cent; and other varied uses, 5 per cent.

## USES

Talc is used mostly in a fine-ground state; soapstone in massive or block form. There are many industrial applications for ground talc, but fewer than a dozen countries use ground talc on a major scale.

In pulp and paper manufacture softness, chemical inertness, high reflectance, hydrophobic and organophilic properties and the particle shape of talc, are characteristics that permit its use as a pitch-adsorbing agent, as a paper filler and as a coating pigment. For filler usage, maximum particle size must be below 20 microns; however, 40 micron grades are also used. For coating applications, particle size must be below 10 microns and close to 1 micron for pitch control.

The ceramic industry utilizes very finely ground talc to increase the translucence and toughness of the finished product and to aid in promoting crack-free glazing. Talc must be low in iron, manganese and other impurities which would discolour the fired product. Average particle size for most ceramics must range between 6 and 14 microns, with 90-98 per cent of material passing through 325 mesh.

In plastics, talc improves dimensional stability, chemical and heat resistances, impact and tensile strengths, electrical and insulation properties. It is used in thermoplastics and in thermosets, mainly in polypropylene, nylon and polyester. Chemical coupling agents are used to enhance the bond between the talc filler and the resin matrix in plastic materials. Talc must be free of iron impurities and grits, and must be superfine with an average particle size below 8 microns.

High-quality talc is used as an extender pigment in paints. Specifications for a talc pigment, as established in American Society for Testing and Materials (ASTM) designation D605-69 (1976), relate to its chemical composition, colour, particle size, oil absorbency and fineness of dispersion. A low carbonate content, a nearly white colour, a fine particle size with controlled particle size distribution and a specific oil-absorption are important. However, because of the variety of paints, precise specifications for talc pigments are generally based on agreement between consumer and supplier. Paint characteristics influenced by the use of talc as extender are gloss, adhesion, flow, hardness and hiding power.

Pharmaceutical industries are well-known users of high purity talc for pharmaceutical preparations and cosmetics, relying on its softness, hydrophobic property and chemical inertness. Finely ground, it is used as a filler in tablets and as an additive in medical pastes, creams and soaps.

Lower-grade talc is used as a dusting agent for asphalt roofing and rubber products, as a filler in drywall sealing compounds, floor tiles, asphalt pipeline enamels, auto-body patching compounds, and as a carrier for insecticides. Other applications for talc include use in cleaning compounds, polishes, electric cable coating, foundry facings, adhesives, linoleum, textiles and in the food industry.

Soapstone has now only very limited use as a refractory brick or block, but, because of its softness and resistance to heat, it is still used by metalworkers as marking crayons. The ease with which it can be carved makes it an excellent artistic medium.

Pyrophyllite can be ground and used in much the same way as talc. In ceramics, it imparts a very low coefficient of thermal expansion to tiles. It must be graded minus 325 mesh and contain a minimum of quartz and sericite which are common impurities. It may also be used in refractories as its expansion on heating tends to counteract the shrinkage of the plastic fraction. Massive pyrophyllite, the compact and homogenous variety, is chiefly used in the manufacture of refractories, although small amounts of the crystalline or radiating variety find similar use. Foliated or micaceous pyrophyllite find use as a filler and ceramic raw material.

## WORLD PRODUCTION AND REVIEW

Talc is widely distributed throughout the world and many countries have been developing deposits. These widespread occurrences enjoy limited international trade except for high-grade materials, where small shipments compete with substitutes. The majority of international trade takes place within Europe; in the Far East between Japan, the People's Republic of China and Korea; and in North America between Canada and the United States.

In 1983, world production of talc and pyrophyllite remained unchanged at about 6.85 million t. Japan is the largest supplier of pyrophyllite with an estimated production of 1.35 million t, and is also the world's largest importer of talc for use in the paper industry as a filler and coating material. The United States is the major producer of talc accounting for 20 per cent of the world total, followed by China with 18 per cent.

In 1983 United States production decreased by 6 per cent although apparent consumption increased by 20 per cent to 857 000 t. For 84 production of talc minerals is estimated at 1.18 million t. Vermont Talc Co., a division of Omya Inc., is planning to double its capacity, adding a Raymond roller mill and a froth flotation plant to its facilities located near Chester, Vermont. In 1983, Engelhard Corporation closed its 80 000 tpy subsidiary, Eastern Magnesia Talc Company, at Johnson, Vermont.

In France, la Société anonyme des talcs de Luzenac (SATL) has been operating, since 1982, an optical sorting pilot plant to increase productivity and to obtain higher quality products from its mines at Trimouns.

China reported exports of 523 000 t of talc in 1982, mainly to Japan, southeast Asian countries and England. Domestic consumption accounts for 68 per cent of the total output; paper making is the major consumer with 60 per cent followed by asphalt products with 14 per cent.

## PRICE

Prices of talc vary according to quality, method of processing, specifications and transportation cost. Since 1982, prices have remained steady with a small average annual increase of about 8 per cent. Canadian prices vary between $35-70 per t for medium-grade talc, $95-160 per t for high-grade talc, $180-250 per t for highly-beneficiated talc, and around $1,000 per t for steatite blocks. However, list prices and actual prices differ as negotiations occur between producers and consumers.

## OUTLOOK

In 1984 Canada, as a supplier of fine talc, benefit from the gap in the market created by the closure of Engelhard's facilities, in Vermont. Aggressive marketing from Canadian producers in the pulp and paper industry also increased sales in the United States. Producers should maintain their market share due to transportation deregulation in the United States, currency exchange rate and economies of scale from their newly installed capacities. In the short run, the demand for talc will maintain a steady growth because of its versatility and because of competitive pricing.

Consumption trends look promising in the pulp and paper, the plastics and the ceramics industries. Markets should hold steady in the manufacturing sectors subjected to cyclical effects such as in the construction area: paints, roofing and gypsum products will show a slight growth relative to economic recovery. The Canadian Construction Association anticipates, for the period 1984-1990, a growth around 0.2-0.6 per cent for investment in the residential sector, and around 4.8-6.5 per cent in the non-residential sector. Appreciable growth is expected in the pulp and paper industry due to the versatility of the talc as a multiple-effects functional filler and pitch-adsorbing agent. Talc will benefit from increased usage as a filler in plastics for the automotive sector, which is also expected to grow in the next few years. Talc consumption will be steady in automotive body patching compounds.

From a 1979 base, the U.S. Bureau of Mines has estimated that the demand for talc and related minerals is expected to increase at an annual rate of about 2 per cent through 1990.

Substitutes for talc are numerous in its major markets: nepheline syenite, kaolin and calcium carbonate in paints; pyrophyllite and feldspar in ceramics; mica and calcium carbonate in plastics; kaolin and calcium carbonate in paper. However, talc is still the primary pitch control agent in the pulp industries.

## PRICES OF TALC

Talc; free on board mine, carload lots, containers included unless otherwise specified: U.S. $ per short ton.

| | |
|---|---|
| New Jersey | |
| mineral pulp, ground; (bags extra) | 18.50-20.50 |
| Vermont | |
| 98% through 325 mesh, bulk | 70 |
| 99.99% through 325 mesh, dry processed, bags | 147 |
| 99.99% through 325 mesh, water beneficiated, bags | 213-228 |
| New York | |
| 96% through 200 mesh | 62-70 |
| 98-99.25% through 325 mesh (fluid energy ground) | 160 |
| California | |
| Standard | 69.50 |
| Fractionated | 37-71 |
| Micronized | 62-104 |
| Cosmetic/Steatite | 33-65 |
| Georgia | |
| 98% through 200 mesh | 50 |
| 99% through 325 mesh | 60 |
| 100% through 325 mesh (fluid energy ground) | 100 |

Source: Engineering and Mining Journal, December 1984.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| CANADA | | | | | |
| 71100-3 | Talc or soapstone | 10 | 12.1 | 25 | 8.0 |
| 29646-1 | Talc for use in manufacture of pottery or ceramic tile (expires June 30, 1984) | free | free | 25 | free |
| 29647-1 | Micronized talc, not exceeding 20 microns | free | 4.5 | 25 | free |
| 29655-1 | Pyrophyllite | free | free | 25 | free |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 71100-3 | 12.1 | 11.4 | 10.7 | 9.9 | 9.2 |
| 29647-1 | 4.5 | 4.4 | 4.3 | 4.1 | 4.0 |

UNITED STATES

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| 523.31 | Talc and soapstone, crude and not ground | 0.02¢ per lb. | | | | |
| 523.33 | Talc and soapstone, ground, washed, powered or pulverized | 4.2% | 3.8% | 3.3% | 2.9% | 2.4% |
| 523.35 | Talc and soapstone, cut or sawed, or in blanks, crayons, cubes, disks or other forms, per lb. | .1¢ | free | free | free | free |
| 523.37 | All other, not provided for | 4.8% | 4.8% | 4.8% | 4.8% | 4.8% |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated 1983, USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241.

## TABLE 1. TALC, SOAPSTONE AND PYROPHYLLITE PRODUCTION, TRADE 1982-84 AND CONSUMPTION 1981-83

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($) | (tonnes) | ($) | (tonnes) | ($) |
| **Production** (shipments) | | | | | | |
| Talc and soapstone | | | | | | |
| Quebec[1] | .. | 1,708,516 | .. | 1,960,844 | .. | 2,430,000 |
| Ontario[2] | .. | 2,753,746 | .. | 4,894,441 | .. | 6,698,000 |
| Total | .. | 4,462,262 | .. | 6,958,685 | .. | 9,128,000 |
| Pyrophyllite | | | | | | |
| Newfoundland | .. | 603,446 | .. | 1,140,659 | .. | 1,120,323 |
| Total production | 70 523 | 5,065,708 | 97 030 | 7,995,914 | 125 650 | 10,530,300 |
| | | | | | (Jan.-Sept. 1984) | |
| **Imports** | | ($000) | | ($000) | | ($000) |
| Talc, incl. micronized | | | | | | |
| United States | 33 604 | 5,508 | 34 718 | 6,123 | 27 544 | 5,241 |
| United Kingdom | 65 | 8 | 46 | 19 | 75 | 11 |
| Italy | 75 | 9 | 42 | 14 | - | - |
| Japan | 151 | 18 | 2 | 3 | 24 | 3 |
| France | - | - | - | - | 36 | 11 |
| Sub-total, talc | 33 895 | 5,543 | 34 808 | 6,159 | 27 679 | 5,266 |
| Soapstone, exc. slabs | | | | | | |
| United States | 139 | 31 | 32 | 4 | 26 | 9 |
| Taiwan | 18 | 2 | - | - | - | - |
| Sub-total, soapstone | 157 | 33 | 32 | 4 | 26 | 9 |
| Pyrophyllite | | | | | | |
| United States | 470 | 40 | 548 | 41 | 483 | 35 |
| Sub-total, pyrophyllite | 470 | 40 | 548 | 41 | 483 | 35 |
| Total talc, soapstone and pyrophyllite | 34 522 | 5,616 | 35 390 | 6,207 | 28 188 | 5,410 |

| | 1981 | 1982 | 1983 |
|---|---|---|---|
| | | (tonnes) | |
| **Consumption**[3] (ground talc available data) | | | |
| Paints and varnish | 9 724 | 8 612 | 7 959 |
| Gypsum products | 5 233 | 2 735 | 3 133 |
| Pulp and paper products | 5 762 | 6 660 | 9 660 |
| Roofing products | 5 565 | 6 631 | 5 671 |
| Ceramic products | 5 300 | 5 546 | 3 376 |
| Toilet preparations | 1 671 | 1 513 | 1 722 |
| Chemicals | 2 479 | 2 734 | 2 577 |
| Rubber products | 1 559 | 2 470 | 3 400 |
| Other products[4] | 1 691 | 1 732 | 1 999 |
| Total | 38 984 | 38 633 | 39 497 |

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Ground talc, soapstone, blocks and crayons. [2] Ground talc. [3] Breakdown by Energy, Mines and Resources, Canada. [4] Adhesives, floor covering, insecticides and other miscellaneous uses.
P Preliminary; .. Not available; - Nil.

## TABLE 2. CANADA, TALC AND PYROPHYLLITE PRODUCTION AND IMPORTS, 1970, 1975, 1979-84

| | Production[1] | Imports |
|---|---|---|
| | (tonnes) | |
| 1970 | 65 367 | 29 999 |
| 1975 | 66 029 | 30 428 |
| 1979 | 90 330 | 50 322 |
| 1980 | 91 848 | 50 774 |
| 1981 | 82 715 | 30 322 |
| 1982 | 70 523 | 34 522 |
| 1983 | 97 030 | 35 390 |
| 1984P | 125 650 | .. |

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments.

P Preliminary; .. Not available.

## TABLE 3. WORLD PRODUCTION OF TALC, SOAPSTONE AND PYROPHYLLITE, 1980-83

| | 1980 | 1981 | 1982P | 1983[e] |
|---|---|---|---|---|
| | (000 tonnes) | | | |
| Japan | 1 749 | 1 545 | 1 492 | 1 464 |
| United States | 1 125 | 1 218 | 1 030 | 967 |
| People's Republic of China[e] | 916 | 898 | 898 | 898 |
| Republic of Korea | 719 | 620 | 591 | 632 |
| U.S.S.R.[e] | 490 | 500 | 510 | 510 |
| Brazil | 413 | 503 | 384 | 500 |
| India | 369 | 367 | 336 | 322 |
| Finland | 317 | 307 | 325 | 300 |
| France | 302 | 309 | 277 | 277 |
| North Korea | 168 | 168 | 168 | 168 |
| Italy | 166 | 163 | 164 | 163 |
| Austria | 117 | 116 | 117 | 116 |
| Canada | 92 | 83 | 70 | 97 |
| Australia | 171 | 91 | 93 | 93 |
| Norway | 88 | 33 | 32 | 36 |
| Other countries | 332 | 303 | 351 | 308 |
| Total | 7 534 | 7 224 | 6 838 | 6 851 |

Sources: U.S. Bureau of Mines Preprints 1983; Energy, Mines and Resources Canada.

P Preliminary; [e] Estimated.

# Tantalum

D.G. FONG

## CANADIAN DEVELOPMENTS

Tantalum mining operations at Tantalum Mining Corporation of Canada Limited's (TANCO) Bernic Lake, Manitoba property remained suspended throughout 1983 and 1984. TANCO, Canada's only tantalum producer, was closed at year-end 1982 and has been maintained on a standby basis pending an improvement in the tantalum market. No sales of tantalum pentoxide were made during the last two years because of low prices and high inventories. Prior to the closure, the company had normally shipped 60 per cent of its output to KBI Division of Cabot Corporation at Reading, Pennsylvania under a long-term contract.

TANCO is jointly owned by KBI (37.5 per cent), Hudson Bay Mining and Smelting Co., Limited (HBM&S) (37.5 per cent) and the Manitoba government (25 per cent), and it is managed by HBM&S under a management contract. In 1984, the company was awarded a grant from the Federal Department of Regional Industrial Expansion to assist in the temporary conversion of the tantalum mill into a pilot mill to produce ceramic grade lithium concentrate. Test samples were shipped to end users for trial production during the later part of 1984.

Highwood Resources Ltd. resumed exploration drilling in the winter of 1983 at the Thor Lake deposit in the Northwest Territories. Thor Lake is located 110 km southeast of Yellowknife on the north shore of Great Slave Lake. The property contains several multi-mineral deposits, each with slightly different mineralization. Exploration work between 1977 and 1981 outlined 70 million t of mineralization with a grade of 0.30 per cent tantalum (Ta), 0.40 per cent columbium (Cb), 3.5 per cent zirconium (Zr) and 1.7 per cent combined rare earths. Additional drilling in the 1983-84 seasons identified a beryllium zone containing 1.789 million t of 0.86 per cent beryllium (BeO).

During 1984, Highwood Resources conducted metallurgical test work on the recovery of tantalum and columbium from the Thor Lake zones. A high recovery of ultrafine tantalo-columbite was achieved using a novel fine particle recovery process. Metallurgical testing on the recovery of beryllium was being carried out at an Ontario laboratory. In view of the attractive grade, Highwood Resources began a prefeasibility study to assess the economics and viability of an open-pit mine and concentrator at the beryllium zone. Tantalum, columbium, rare earths and other associated elements in this deposit could be produced as byproducts or coproducts.

## WORLD DEVELOPMENTS

The world's major tantalum producing countries are Canada, Australia, Brazil, Thailand, Nigeria, Zaire and Mozambique. Canada was, until 1982 the world's largest tantalite producer, supplying about 15 per cent of the world's tantalum requirements, while Thailand was the world's largest supplier of tantalum-bearing tin slag, a byproduct of tin mining. During 1983, when Canada temporarily ceased production of tantalum, Brazil continued to produce at an annual rate of 68 t. Australian production in the year to June 1983 was 29.64 t, about 35 per cent of plant capacity.

Australian tantalum production to June 1984 increased 61 per cent to 47.74 t. The higher output in Australia stemmed from an increased emphasis on the production of tantalite rather than tin. Australian tantalum is produced with tin which, during the last few years, has faced export quotas imposed by the International Tin Council (ITC).

Greenbushes Tin N.L. of Perth, Australia's largest tantalum producer, was proceeding with its mine expansion project. At the end of 1983, the company borrowed $20 million from two banks to finance a new processing plant and underground mine

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developments. The mine expansion is expected to raise Greenbushes' annual production capacity to 204 t of tantalum pentoxide ($Ta_2O_5$) by mid-1985. Production could be further increased to 272 tpy whenever markets warrant.

Greenbushes also commenced sales of tantalite to the U.S. General Services Administration (GSA) during the last quarter of 1983. The company was awarded a contract to supply 54.4 t of tantalite concentrates, with the stipulation that shipments be completed before October 14, 1984.

Thailand Tantalum Industry Corp. Ltd. (TTIC) signed an agreement in late 1983 to borrow \$US 53.5 million from International Finance Corporation (IFC) to build a tantalum recovery plant in Phuket, Thailand. The new plant will include a smelter and a chemical treatment plant with an annual capacity to produce 300 t of $Ta_2O_5$ and 300 t of columbium pentoxide ($Cb_2O_5$). Feedstocks will consist of high-grade tin slags, tantalo-columbite, and struverite concentrates. TTIC also planned to further process up to 7 000 tpy low- to medium-grade tin slags to recover an additional 100 to 150 tpy of $Ta_2O_5$. The IFC, an affiliate of the World Bank, has agreed to buy a 12 per cent interest in the project for \$US 3.9 million.

Production at the Phuket plant had originally been scheduled to commence in 1984 but this was later postponed to 1986. When the project was proposed in 1980, the Thai Board of Investment gave TTIC exclusive rights for $Ta_2O_5$ production for eight years, and agreed to place a ban on the export of tin slags one year before the start-up of the Phuket plant.

Bureau des Recherches Geologiques et Minières (BRGM) completed an initial feasibility study in 1983 of Echassieres, a new tin-tantalum deposit near Vichy, in southern France. The Echassieres deposit contains 55 million t grading 0.023 per cent $Ta_2O_5$, 0.13 per cent tin (Sn), 0.022 per cent $Cb_2O_5$ and 0.71 per cent lithium oxide ($Li_2O$). The initial plan was to have a 170 000 tpy mining operation together with a processing plant to recover 150 to 160 tpy of tin and 35 tpy of $Ta_2O_5$.

## USES

Tantalum is a refractory metal with unique physical, electrical and chemical properties which make it useful in a number of industrial applications including electronic, metal making, chemical equipment and high temperature alloy industries.

Capacitors are by far the largest users of tantalum, accounting for about 55 per cent of the world demand in 1984. Tantalum has proved its superiority as a metal for electronic capacitor anodes because of its inertness and the stability of its electrolytic oxide film. Tantalum capacitors are used in all forms of electronic systems such as computers, communication systems and military applications where compactness and reliability are key factors.

Tantalum cemented carbides are used mainly in mixtures with other carbides such as tungsten, titanium, columbium, chromium, vanadium, molybdenum and hafnium. The addition of tantalum carbide to other metallic carbides imparts a greater cratering resistance, as well as the ability to be machined at much higher cutting edge temperatures. Cemented carbides are used in cutting, turning, and boring tools, and wear resistant parts and dies.

At low to moderate temperatures, tantalum's high resistance to corrosion by most acids and the complete inertness to many chemicals has made it the preferred material in severe environments. The metal is used mainly as thin sheet linings in chemical equipment. Explosive cladding techniques are used to clad thin tantalum sheets on container walls, which enable it to be competitive with substituting materials.

Tantalum is an important addition in special nickel- and cobalt-base superalloys that are used in high-temperature applications such as jet engines and gas turbine parts. The addition of tantalum increases the strength of these superalloys and improves the high temperature performance in terms of fuel efficiency and durability. Pratt and Whitney of United Technology Inc. has developed a high tantalum content single crystal superalloy, PW1480, for use in jet engines. The single crystal technology has been licensed to the U.S. government for applications in the space shuttle program.

## PRICES

TANCO's published tantalite price remained unchanged at \$US 45 a lb contained $Ta_2O_5$ during 1983 and 1984. The spot market price increased to \$US 28-31 in October, 1983 from \$US 20-25 a lb at the beginning of the year. It increased again to \$US 31-33 in August 1984, as consumption continued on a recovery course. The published producer price for tantalum carbide, in 1984, quoted at $US 51 a lb, was the first published list price since 1979, an evidence of growing stability in the carbide market.

## OUTLOOK

The tantalum market is expected to continue its recovery in 1985. Western world production is forecast to increase by 10 per cent in 1985 to about 2.7 million lbs. A modest improvement of 2 to 3 per cent is indicated for 1986. Inventories can be expected to decline to a normal level in relation to demand. However, prices are unlikely to surpass the $US 40 a lb mark because consumption growth will likely be matched by increases in output.

Among the end uses, capacitors will remain the largest consuming segment. However, the growth in consumption of tantalum powder for capacitors will continue to be hampered by technology advances, the continuing improvement of capacitance value of the tantalum powder and miniaturization, each of which will contribute to a lower powder requirement per unit capacitor. Also, because of a previous history of widely fluctuating prices and limited supplies, consumption growth has been affected by substituting materials. In this regard, tantalum capacitors are not expected to recapture much of their lost markets because end use applications such as personal computers are relatively inflexible to design changes. Once tantalum is designed out of a particular application, it is unlikely that the production process will be changed just because of a lower price. Nevertheless, the fast growing electronics industry is expected to provide new opportunities for expanding the tantalum capacitor market. The increase in consumption of tantalum units for new applications could more than offset the miniaturization and substitution effect.

Tantalum cemented carbide is used mainly in cutting tools in the metal working industries. The demand for tantalum from this segment has been greatly hampered by the recessionary effect of the early 1980s and the increased usage of titanium coating and other substitution materials. Despite a recent strong recovery in the automobile industry, consumption in this segment has remained low. The consumption of tantalum in cutting tools is expected to grow at a slower rate than the averaged 3.25 per cent a year in other end-use sectors. However, the carbide cutting tool technology is continuously advancing and the development of new alloys of tantalum and columbium could change the demand pattern in the future.

Markets for tantalum mill products are highly sensitive to the business cycle because the use of these products is closely linked with capital investments, mainly in chemical process equipment. Capital investments have been depressed for several years and, even with the current economic recovery, the chemical industry continues to buy equipment at a low rate. In the longer term, the demand for tantalum from this sector is expected to outperform the other end-uses. The consumption of tantalum mill products is expected to grow at 4 to 5 per cent a year.

Tantalum-bearing superalloys are used mainly in jet engines. In recent years, tantalum consumption in this sector has expanded rapidly, despite a poor performance in the aircraft manufacturing industry. The use of substantial quantities of tantalum in jet engines for the Boeing and Airbus aircrafts was the main factor. In 1984, tantalum usage in this sector accounted for about 10 per cent of the total consumption, as compared with 3 per cent five years ago. A significant growth rate is forecast in this application, in view of the high temperature efficiency achieved from tantalum.

The main source of western world tantalum supply, accounting for about three-quarters, is the tin mining and smelting industry. Tantalum is produced in association with tin operations in countries such as Thailand, Australia, Malaysia, Brazil and Africa. Because of this relationship, future supplies of tantalum will, to a great extent, continue to hinge on the well-being of the tin industry. Also, the continued imposition of tin export quotas by the International Tin Council could be a major barrier to any significant increase in tantalum supply.

The majority of tantalum processing is carried out in the highly industrialized nations: the United States, West Germany and Japan. Processors in these countries normally carry a large stock of tantalite concentrates and tin slags, often equivalent to one to two years of supply. The processors thus can continue to have a significant influence over the tantalum market.

The tantalum processing industry could soon undergo an important structural change. Thailand has been the largest single source of tantalum raw materials for the western world processors. However, with the start-up of the TTIC upgrading plant in Thailand, tantalum-bearing tin slags will cease to come from that country. This will likely result in a shortage of feed materials for the processing industry in other parts of the world. Although the shortage could be partly offset by increased output from Australian sources, some processors may have to make adjustments by either switching to intermediate products or by phasing down their operations.

Canadian tantalum production could increase during the next decade, particularly if Highwood Resources proceeds with its beryllium and rare earth mine development. Highland Resources could produce tantalum as a byproduct or coproduct of beryllium.

**TABLE 1. CANADA, TANTALUM PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975 AND 1979-84**

| | Production[1] | Imports[2] | | Consumption |
|---|---|---|---|---|
| | | Primary forms and fabricated metals | | Ferrocolumbium and Ferro-tantalum-columbium, Cb and Ta-Cb |
| | $Ta_2O_5$ Content | Tantalum | Tantalum Alloys | Content |
| | | (kilograms) | | |
| 1970 | 143 800 | .. | .. | 132 449 |
| 1975 | 178 304 | .. | .. | 215 910 |
| 1979 | 158 845 | 6 901 | 2 503 | 360 152 |
| 1980 | 115 261 | 21 280 | 12 112 | 486 251 |
| 1981 | 103 949 | 2 769 | 5 043$^r$ | 455 500$^r$ |
| 1982 | 59 276 | 1 759 | 1 146 | 356 000 |
| 1983 | - | 1 742 | 332 | 352 000 |
| 1984P | - | 4 428 | 1 389 | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada; U.S. Department of Commerce.
[1] Producers' shipments of tantalum ores and concentrates and primary products, $Ta_2O_5$ content. [2] 1984 imports based on nine month statistics.
P Preliminary; - Nil; .. Not available; $^r$ Revised.

## PRICES

Prices as quoted in Metals Week in December 1983 and 1984, U.S. currency.

| | 1983 | 1984 |
|---|---|---|
| | ($) | |
| Tantalum ore | | |
| Tantalite, per kg of pentoxide, Tanco price | 99.21 | 99.21 |
| Spot tantalite ore | 61.73-68.34 | 68.34-72.75 |

**TARIFFS**

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| CANADA | | | | | |
| 32900-1 | Columbium and tantalum ores and concentrates | free | free | free | free |
| 35120-1 | Columbium (niobium) and tantalum metal and alloys in powder, pellets, scrap, ingots, sheets, plates, strips, bars, rods, tubing or wire for use in Canadian manufactures (expires June 30, 1984) | free | free | 25 | free |
| 37506-1 | Ferrocolumbium, ferrotantalum, ferro-tantalum-columbium | free | 4.7 | 5 | free |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 37506-1 | 4.7 | 4.5 | 4.3 | 4.2 | 4.0 |

UNITED STATES

| | | | | | | |
|---|---|---|---|---|---|---|
| 601.42 | Tantalum ore | free | | | | |
| | | 1983 | 1984 | 1985 | 1986 | 1987 |
| | | | | (%) | | |
| 629.05 | Tantalum metal, unwrought and waste and scrap (duty on waste and scrap suspended to June 30, 1982) | 4.4 | 4.2 | 4.0 | 3.9 | 3.7 |
| 629.07 | Tantalum, unwrought alloys | 6.2 | 5.9 | 5.6 | 5.2 | 4.9 |
| 629.10 | Tantalum metal, wrought | 7.3 | 6.8 | 6.4 | 5.9 | 5.5 |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated 1983, USITC Publication 1317; U.S. Federal Register, Vol. 44, No. 241.

# Tin

### A. BOURASSA

World tin consumption in 1983 marked the end of the downward trend which began in 1973. Preliminary data even suggests a slight recovery in world consumption in 1984. The domestic market followed this world trend. Since April 1982, the tin producing members of the Sixth International Tin Agreement (ITA) have been subject to export controls, in order to re-establish the balance between the supply and demand of tin on the markets. These controls caused a marked decline in production in 1983 and an additional drop in 1984. The operations of the buffer stock manager have helped keep tin prices relatively stable during the past two years. However, these operations have been complicated by the major fluctuations in a number of currencies. Development work is continuing on a large tin deposit in Nova Scotia. Commercial production is expected to begin in October 1985.

## CANADA

Canada still produces relatively little tin, but ranks among the dozen largest, non-communist consuming countries. Production of tin in concentrates and tin-lead alloy increased in 1983 and 1984.

Canada relies on imports for its tin requirements, except for small amounts recovered from recycled solders and detinning, and in primary tin-lead alloy production. Consumption was falling for several years, but this trend slowed down in 1983 and could be reversed in 1984.

Tin concentrates are recovered as byproducts of base-metal mining by Cominco Ltd. at Kimberley, British Columbia. Cominco also recovers a tin-lead alloy containing about 8 per cent tin at its Trail, British Columbia smelter and produces small quantities of special high purity tin from imported commercial-grade metal. Some Yukon placer gold deposits contain tin and tungsten and small quantities of these metals have been recovered in placer mining operations.

Tin mineralization is known in various parts of Canada, and higher prices in recent years encouraged exploration. The most promising reported discovery is the East Kemptville tin deposit near Yarmouth, Nova Scotia, discovered by Shell Canada Resources Limited in 1978. The deposit is estimated to contain some 56 million t grading about 0.16 per cent tin, recoverable by open-pit mining. In October 1982, the property was purchased by Rio Algom Ltd., Toronto. Work is in progress to begin production by October 1985.

The mine will produce concentrates that will be exported for smelting. The mill's capacity is set at 9 000 tpd of ore. The concentrates produced will be the equivalent of over 4 000 tpy of tin, or close to the current domestic tin consumption level. The life of the mine is expected to be 17 years. Concentrate production will peak early in the operations, then fall off with the passing years.

The total cost of the project is assessed at $150 million. Although there are other known tin deposits and exploration work continues across the country, no other plans were announced for their development.

## THE INTERNATIONAL TIN AGREEMENT

Tin is the only metal for which there is an intergovernmental agreement involving producing and consuming countries that contains economic provisions for market stabilization. Successive five-year pacts have been in force since 1956. The Sixth International Tin Agreement entered provisionally into force on July 1, 1982, to replace the Fifth Agreement that had been extended by one year to allow more time to negotiate its successor. Provision is made in the agreements for market stabilization measures, including purchases and sales under a buffer stock arrangement, and the implementation of export controls on producing members if buffer stock operations are insufficient to protect the floor price.

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Upon its entry into force, countries that had either signed or ratified the Sixth Agreement comprised six producers (Australia, Indonesia, Malaysia, Nigeria, Thailand and Zaire), which together accounted for 70 per cent of reported 1982 world tin mine production, and 18 consuming members, including Canada, which together accounted for 51 per cent of 1982 world tin consumption. Leading members of the Fifth Agreement that did not join the Sixth included the United States, U.S.S.R. and Bolivia.

The Sixth Agreement, as negotiated, provided for a buffer stock of up to 50 000 t of tin: 30 000 t financed by mandatory cash contributions from both producing and consuming members and 20 000 t by borrowing, with member government guarantees if necessary. Mandatory contributions from consuming members were introduced for the first time in the Sixth Agreement, replacing voluntary consumer contributions in the Fifth Agreement. The Sixth Agreement also provides for the imposition of export controls on producer members by a two-thirds majority vote when the buffer stock contains at least 35 000 t of tin, or by a simple majority vote when the buffer stock level reaches 40 000 t. Export controls are reviewed at each quarterly Tin Council meeting but may be eased automatically as the price improves.

Implementation of the Sixth Agreement required that countries accounting for at least 65 per cent of both production and consumption ratify the agreement by April 30, 1982. Although this level was not achieved on the consumption side, countries that had signed the agreement agreed to implement it provisionally on July 1, 1982. The member-financed buffer stock was reduced from 30 000 t to 19 666 t but the loan-financed portion remained at 20 000 t. Stockholdings necessary to permit implementation of export controls were reduced proportionately. Price levels established under the new agreement remained unchanged, with a floor of 29.15 Malaysian ringgets ($M) per kg and a ceiling of $M 37.89. The buffer stock must be a net buyer in the lower range ($M 29.15 - $M 32.06) and a net seller in the upper range ($M 34.98 - $M 37.89). These ranges were last changed in October 1981. Under the export control scheme, producers may stockpile excess tin in concentrates up to a maximum of about 25 per cent of their base annual production, to be held for smelting and sale upon removal of the controls.

## ASSOCIATION OF TIN PRODUCING COUNTRIES

The Governments of Malaysia, Indonesia and Thailand were reported to have reached agreement in principle in mid-1982 to establish a tin producers association. This initiative was generally perceived as an indication of concern about the implementation of the Sixth ITA and about its ability to effectively enforce tin prices, if it were implemented. Thus, from the outset, Malaysia pressed for market stabilization measures, should the international agreement prove ineffective.

The Association was officially formed on August 13, 1983, after lengthy negotiations. It had five members: Bolivia, Malaysia, Indonesia, Thailand and Zaire. Nigeria joined on August 31 and Australia in November of the same year. These seven participating members produce 75 per cent of the tin in non-communist countries. The Association's head office is in Kuala Lumpur, Malaysia.

The main objectives proposed by the Association are the promotion of tin use through research and technological development, support of the Sixth ITA's market stabilization activities and an increase in the economic fallout from tin production in the economies of member countries.

Members agree on objectives and the nature of the problems affecting tin markets, but do not all agree on what measures to take if the Sixth ITA is unable to ensure market stability.

The Association works closely with the International Tin Research Council in London, England and the South East Asia Tin Research and Development Centre, in Malaysia. Both of these organizations are already financed by these same tin producers.

## TIN MARKETS AND PRICES

Trends in reported annual world tin production, consumption and prices since 1970 are shown in Table 3. Since 1973, world tin consumption has trended downwards because of substitution away from tin in some end uses and because of technological developments that have decreased the quantities of tin for other uses. Although this decline halted momentarily in 1983 and 1984, it is still too early to speak of a recovery. The structural factors that caused the decline in previous years are apparently still at work. However, one can probably speak of consumption stabilization around the 1984 level, due to the growth potential of certain tin uses.

The production of tin in concentrates peaked in 1982, and primary production reached a high in 1979. Both recorded a marked decline in 1983 and 1984. These drops are the result of export restrictions imposed on the producing members of the Sixth ITA. Although Bolivia did not ratify this agreement, it had agreed to apply the same constraints to its own production, if necessary. Brazil practically doubled its production since 1982. The reader will note the growing difference in Table 3 between tin production and consumption from 1978 to 1982.

Statistics in the accompanying tables do not include information on most centrally planned countries. Leading producers among these countries include the U.S.S.R. and the People's Republic of China, for which the United States Bureau of Mines estimates production in 1983 at 37 000 t and 15 000 t, respectively. The Democratic Republic of Germany is estimated to have produced 1 700 t in 1983. This tin is generally consumed domestically, although China is a net exporter to the west (estimated at 2 500 t in 1983) while the U.S.S.R. and East Germany had estimated combined net imports from the west of over 17 000 t in 1983.

A substantial tonnage of tin production, which is included in the accompanying tables, is of unspecified origin. This was estimated at 16 000 t in 1983 and 10 000 t in 1984. These tin concentrates are generally channelled through the free port of Singapore where they are smelted or re-exported to smelters elsewhere. Their origin is believed to be largely southeast Asian countries, particularly Thailand, having been smuggled out of these countries to avoid payment of royalties and export duties and, since 1982, to bypass export controls.

In 1983 and 1984, tin prices were subject to the fluctuations of various foreign currencies. Two currencies are especially relevant to the tin market: the Malaysian dollar and the British pound. The latter is important because most tin market financial transactions occur on the London Metal Exchange. London is therefore an influential centre for determining the international price of tin.

The Malaysian market is an important physical market; in addition, the floor and ceiling prices used by the buffer stock manager are set in Malaysian dollars. This is why watching the price of tin on the Malaysian market is a priority for the manager. This price, in turn, influences the London market, where the manager will also intervene to attempt to maintain parity between both markets. In the past two years, the Malaysian and American dollars have evolved in a similar manner on the exchange market, but the British pound recorded major falls compared to American currency. This is why, depending on the market under consideration, tin prices have been relatively stable or on the rise.

Since October 17, 1981, there has been no change in the floor and ceiling prices set under the aegis of International Tin Agreements. The floor price has remained at $M 29.15/kg and the ceiling at $M 29.15/kg. In 1983, the price of tin on the Malaysian market stayed mainly in the margin of $M 30.00 to $M 31.00/kg. The 1984 prices, however, remained almost constantly at the $M 29.15 floor price. However, the behaviour of tin on the London market is entirely different. On this market, tin rose from its January 1983 price of £7,669/t to almost £10,000/t by the end of 1984: an historic record for this metal. Despite this rise, the London price was frequently below the floor price equivalent in Malaysian dollars. The buffer stock manager's interventions on the London market to maintain a certain parity between both markets, also contributed to this rise in the price of tin. The price of tin for the majority of world tin consumers therefore rose considerably in the past two years, despite a very abundant supply. Accordingly, the competitive position of tin is at a disadvantage. One encouraging sign on the market is that tin stocks are on the decline. In 1984, they dropped by one-half on the London market, or by approximately 20 000 t. This reduction is the result of export restrictions imposed on producing members of the Sixth ITA. Export cutbacks have been raised from 36 per cent in early 1983, to 39.6 per cent in July, 1983. Unfortunately, the stocks held by the buffer stock manager did not experience these declines and are still at over 55 000 t, of which approximately 40 per cent are held under the terms of the Fifth ITA; he has been unable to bring them back on the market to date.

The United States General Services Administration (GSA) continued offerings of tin from the strategic stockpile. Sales in 1983 totalled 2 860 t, and should not exceed 2 400 t in 1984 (all GSA figures are in long tons). Total sales by the end of 1984 were about 15 382 t, under a program begun in 1980. The goal for the United States strategic stockpile is 42 700 t, whereas the stockpile actually contained over 188 000 t at the end of 1984. By October 1, 1984, sales of 20 000 t were authorized. Although GSA sales represent only a small percentage of the total market, producers believe that they place great downward pressure on prices, especially under the current unfavourable circumstances. Pressure has been exerted on the GSA to suspend sales until the market has recovered.

The Penang market in Malaysia was a physical market in tin. Prices were set by the two large tin smelters in the region, using a relatively closed process. Since 1980, palm oil and rubber have been traded on the exchange in Kuala Lumpur. In October 1984, this exchange replaced the Penang market and also deals in tin. It operates like the London exchange and members of the Sixth ITA recognized this market for the operations of the buffer stock manager. This new market, like Penang's, still allows only physical transactions.

## WORLD DEVELOPMENTS

For two years, tin concentrate production in Australia has fallen by 30 per cent, to 8 600 t in 1984, while metal production fell by 10 per cent to 2 800 t. This reduction was caused by export controls. Tasmania is still the main tin mining centre, with the Renison Ltd. mine, which yields over 40 per cent of the total production. This mine produced 3 800 t in 1984. Because of tin production restrictions, Renison Goldfields Consolidatd Ltd., the parent company, is increasingly orienting its exploration toward base metals and gold. Aberfoyle Ltd., controlled by Cominco, which has 47 per cent of the shares, has two tin mines: in Cleveland and Ardlethan. Despite temporary closures and a reduction in operations, production exceeded the allowable quota. Therefore, by the end of 1983, tin inventories had been assessed at close to $A 10 million. The company, with 50 per cent of its revenues still coming from tin, is turning toward diversification in order to expand. The Tin Creek Mining alluvial mining project at Granite Creek began production in early-1984. This combined gold and tin extraction project received a tin production quota of 76 tpy. Greenbushes Tin Mining obtained a $15 million loan for its tin-tantalum mine at Greenbushes. The company also concluded an agreement with Barbara Mining Corp. for 50 per cent participation in the tin-tantalum project in Bynoe, Northern Territory. In June 1984, Endeavour Resources Ltd. started up its alluvial gold-tin-tantalum mine in Moolyella, Western Australia. Great Northern Mining Corp. stopped its copper production in February 1984, but continues to mine tin according to the allowable quota of 40 t quarterly. In August 1984, Metals Exploration Ltd. announced the beginning of production at the tin alluvial project in Gibsonvale, New South Wales. In June 1984, Shell Company of Australia Ltd. purchased from North Broken Hill Holdings a 50 per cent share in the Collingwood tin property in Northern Queensland. A three-year exploration program is being prepared.

Burma's production continues to rise. During the fiscal year ending March 31, 1984, tin in concentrates production rose to 2 240 t, compared to 647 t the previous year. The Rangoon smelter, in operation since 1982 and built with assistance from North Korea, produced 500 t of metal last year. In 1983, Burma exported 717 t of concentrates and 320 t of metal.

Bolivia was a member of the first five International Tin Agreements, but refused to ratify the sixth. However, it maintains close ties with the producing members of the Sixth ITA, as it belongs to the Association of Tin Producing Countries. It has also agreed to make its tin production policy conform with that of the Sixth ITA members. However, the reductions in tin concentrate and metal production over the past two years are probably as much the result of export controls as of Bolivia's serious economic problems. It can no longer meet the deadlines for its enormous foreign debt of $3,700 million, and the tin industry is suffering the effects of this difficult situation.

The mining and metallurgical industry is important for Bolivia. It accounts for 80,000 jobs, 25 per cent of government revenue and one-half of foreign exchange earnings. The tin industry represents 60 per cent of the country's mineral industry. Most of Bolivia's mining industry belongs to the state-owned Corporacion Minera de Bolivia (COMIBOL).

However, there are many small mining developers and cooperatives.

COMIBOL produces approximately 75 per cent of tin concentrates in Bolivia, but production has been declining steadily for a number of years. This fall has been caused by decreasing ore grades and reserves, more difficult mining conditions, production costs that exceed prices, and labour problems. COMIBOL was unable to obtain funds to modernize its operations and purchase spare parts for equipment. After many strikes, COMIBOL was restructured; workers are now in the majority on the board of directors.

Tin concentrate exporting by private producers is prohibited. All concentrates must be sold at the smelter in Vinto or the Banco Minera, both state-owned and the only authorized exporters of excess concentrate.

An ambitious $750 million five-year development plan was proposed for the country's mining and metallurgical industry. However, it is doubtful whether aid organizations will grant a large portion of the aid requested. Bolivia recently obtained a $24 million loan from the Inter-American Development Bank to develop the country's small- and medium-sized mining operations.

Tin production in Brasil increased considerably over the past two years. Tin concentrate production doubled to 17 700 t in 1984, while metal production increased by 80 per cent to 16 900 t. This increase occurred at the same time as large surpluses appeared on the market and coincides with the implementation of export restrictions by producing members of the Sixth ITA. Brazil did not ratify this Agreement.

The government encourages growth of this industry, as it acquires currencies that help repay the country's massive foreign debt. Rising mining production comes mainly from the new mine in Pitingo, in the Amazon, 200 km north of Manaus. This mine belongs to Paranapanema, Brazil's largest producer; in 1984, its production was estimated at 10 000 t. Paranapanema has its own smelter, with a capacity of 12 000 tpy in Sao Paulo, where it treats all the concentrates coming from the alluvial mines in Randonia, Mato Grosso and Para.

The second largest producer is Brascan Recursos Naturais, whose interests are held jointly by British Petroleum and Brascan of Canada. In 1984-85, Brascan will invest $66 million in the Rondonia tin operations. Brascan production in 1984 was estimated at 3 500 t. Brumadinho is the third producer in Brazil. Its production was estimated at 2 400 t in 1984. The country has a number of smelters with a total capacity estimated at 24 000 tpy. Exporting of tin concentrates is prohibited in order to maximize the added value of exports. The country consumes approximately 4 000 tpy of tin; the remainder is exported. It is generally believed that Brazil will continue to increase its production in the future, although at a slower rate. Production is expected to reach 20 000 tpy by the end of the decade. The country's mine operating costs are unknown, but the remoteness of the deposits probably generates high costs. The main Brazilian producers are continuing important exploration programs in the country's alluvial regions. Tin is still being sought, although the emphasis is now more on gold.

India has been a tin producer since 1984. A small mine was opened in Koraput, Orissa. Production will be only 30 tpy. India consumes over 2 000 tpy of tin.

Indonesia's concentrate production fell by one-third between 1982 and 1984, due to the export controls. Metal production was reduced by one-quarter. However, Indonesia is the largest tin producer after Malaysia. In order to increase tin producers' profitability, the government lifted the 10 per cent tax on all tin exports in July 1984. Government-owned P.T. Tambang Timah accounts for over 75 per cent of Indonesian production. Like the other producers, it suffered 60 per cent increases in the cost of its petroleum products in early-1984. These products account for about 50 per cent of production costs. At the end of 1984, it received delivery of a new dredge, Singkep I, which will operate in the Kundur Laut region near Singkep, where a washing plant has already been built. In cooperation with P.T. Krakatau Steel and P.T. Nusaniara Ampera Bakti, it is continuing construction at Cilegon, Java, of a tinplate mill with a capacity of 130 000 t, which will ensure the country's self-sufficiency in tinplate. P.T. Koba Tin, the second largest tin producer, has produced approximately 5 000 t of tin at its mine on Banyka Island. This company is jointly-owned by P.T. Tambang Timah and Kajaura Mining Corp. Ltd. of Australia. Broken Hill Proprietary Indonesia was placed on sale by its Australian parent company. It operates the Kilapa Kampit mine on Belitaung Island. There are enough attractive tin deposits identified in Indonesia to allow for a substantial increase in production when the market permits.

Malaysia is still the world's largest producer of tin. In absolute terms, it is therefore the producer that suffers most from export restrictions. Since 1981, the last year of operation without controls, 10,000 jobs were lost, almost 200 mines were closed and 25 dredges became inactive. Annual tin in concentrate production fell by 20 000 t. In 1984, there were fewer than 25,000 jobs, 530 mines, 34 dredges and 39 000 t of production. Financial losses were widespread among the small producers, who had to stop operations; the profitability rate of the largest companies fell considerably. Kuala Langat Mining, formed to mine the largest tin deposit in the state of Selangor, continues construction of its facilities. However, the absence of production quotas is causing uncertainty for this project, which is to begin in 1986. Known reserves in Malaysia are falling, but a number of apparently promising territories still remain; exploration of these areas will begin once government permission is issued.

Nigeria's tin industry continues to face serious difficulties. The alluvial industry has disappeared, and the only remaining mines are located in the central plateau region. The allowable quotas are too low to generate sufficient revenues for the return on the investments that would be needed to modernize or increase the production of increasingly deep mines. The government is studying the possibility of merging the five major producers into a single state-owned company, Nigerian Tin Mining Co., in order to rationalize operations. The government already holds majority shares in the five companies. The Makeri Smelting Co. smelter, the only one in Nigeria, now receives so little tin that it operates for only 10 per cent of the year.

The production of concentrates at the San Rafael mine south of Peru has now exceeded 2 200 tpy since the introduction of a new flotation circuit in 1982. This mine, owned by Minsur S.A., is located at an altitude of 4 800 m, 180 km from Juliaca. Originally a copper mine, its tin grades have been improving as the depth of the mine increases. This region is the continuation of Bolivia's tin belt and there appears to be potential for new discoveries.

In the United Kingdom, tin production sagged by a few tonnes in 1983, but rose again to 4 400 t in 1984. This is the highest level since World War I. Although the United Kingdom is a member of the ITA, it is classed as a consumer and therefore its production is not constrained by export controls. Each of the three major tin producing companies in the country implemented expansion programs. The Geevor mine has just completed expansion of its mill, thus increasing its capacity by 25 per cent. With this additional capacity, it will be possible to treat surface tailings and increase underground production if the exploration program in the Batallack region uncovers sufficient reserves. Geevor has also requested permission to mine the alluvial deposits in the Hayle River. The recent £9 million modernization program at the South Crofty mine increased production to 1 800 t in 1984. Wheal Pendarves, a subsidiary of South Crofty, suspended its operations at the end of 1984, as its reserves were depleted. An exploration program currently in progress could, however, result in the mine's reopening in one or two years. Carnon Consolidated Tin mines anticipates the Wheal Jane/Mt. Wellington complex production to increase to 2 500 t in 1985; this is a rise of 850 t over current capacity. The company is also considering development of the Bissoe Valley project, which involves the treatment of old tailings and estuarine muds. This production could reach 650 tpy. The Wheal Concord mine, in the hands of a receiver for 15 months, was repurchased by CTS Mining in June 1984. The latter wishes to reopen the mine and plans an ambitious expansion program over two or three years. Marine Mining Consortium Ltd. continues construction of its mill in Gwithian; the company will dredge the ocean floor, where residues from mines in the Cornwall region were deposited for centuries. It would grade one kg of tin for two t of residue. The amount of tin produced in the country's smelters has fallen drastically for a number of years. However, the increased local production of concentrates and the treatment of concentrates from Canada will cause a rise by 1985.

Rwanda has requested financial assistance from the European Economic Community's Sysmin program, in order to modernize its tin industry. It has also approached the European Development Bank and the International Finance Corp. Small mining operations produce 60 per cent of the tin concentrate, estimated at 1 275 t.

Thailand's production, like that of other producers in southeast Asia, fell in the past two years. After a 23 per cent drop to 19 942 t, tin in concentrate production rose slightly in 1984 to 22 000 t. The decline was therefore smaller than in neighbouring countries, but this could contribute to the increase in stocks. Metal production fell by 7 000 t to 18 467 t and should increase by only 400 t in 1984. In September 1983, the government cut royalties on tin by the equivalent of $US 0.35 to $US 1.15 per pound. This measure came in response to pressures from producers who were caught between high taxes and costs, and falling prices on the London market. In March 1984, the government also cancelled the new tin mining permits in order to facilitate the decrease in production. Despite a difficult situation, a number of companies, among them, Metals Exploration and Development Co., a subsidiary of Billiton Int'l, Sea Minerals Ltd., a subsidiary of Aakom Thai, Tongkak Harbour and IFC Ltd., maintained important exploration programs, particularly along the Andaman coast. In 1983, Sea Minerals announced an interesting discovery 25 km from Phuket. In June 1984, it announced a 36 million baht increase in its capitalization, in order to continue its exploration programs. In 1983, the government signed a $25 million agreement for geophysical surveys of the entire territory. The project was granted to Kenting Earth Sciences Ltd. of Canada. The Thaisarco smelter in Phuket operated at only one-half of its 38 000 t capacity. The Thai Pionneer smelter was closed because of financial problems. The Cha-am Pineapple Tinplate Co.'s tinplate production project has been delayed and will probably not be completed before 1986. The only current tinplate producer, Thai Tinplate Mfg. Co., has installed a new production line that will increase its capacity to 150 000 tpy.

In 1983, Zimbabwe produced 1 235 t of tin, or 38 t more than in 1982. This slight increase is due to the operation of a residual tin recovery unit at the Kamativi mine.

## OCCURRENCE AND RECOVERY

About 80 per cent of the world's tin output is derived from alluvial deposits. The principal production methods are bucket-line dredging and gravel pump operations. Suction dredges are also used, but they tend to be less efficient than the bucket-line method. Other methods are hydraulicking and dulang washing. Tin is recovered as cassiterite ($SnO_2$) and is often associated with other heavy minerals such as ilmenite, zircon, wolframite (tungsten), tantalite and others.

Economic grades of placer deposits generally range from 0.15 to 0.40 kg of tin per cubic metre of sand, or from 0.008 to 0.02 per cent tin. Leaders in placer tin production are Malaysia, Indonesia, Thailand and, more recently, Brazil.

Lode mining, though less important than alluvial mining, still accounts for most of the tin output of Bolivia, Australia, Britain and South Africa. Countries of the communist bloc, notably The People's Republic of China and the U.S.S.R., are also important producers of tin from lode as well as alluvial deposits. Viable lode deposits normally range in tin grade from 0.4 per cent or less in open-pit mines to 0.9-1.0 per cent or more in underground mines. Silver, tungsten, bismuth and lead are common byproducts of lode mines. Cassiterite is the predominant tin-bearing mineral of lode deposits but stannite, a copper-tin-iron-bearing sulphide, is of some importance.

Average grades in both placer and lode mining tended to decline during the 1970s and early-1980s, and this trend is expected to continue. Productivity improvements have offset part but not always all of this decline and real tin production costs have also risen, exacerbated by high royalty and tax rates levied by some producing countries.

Concentrating processes for alluvial and most lode tin are based on relatively simple gravity separation methods that produce concentrates ranging from 50 to 76 per cent tin. Magnetic and electrostatic separation are also used. However, mill recoveries of tin from lode deposits often are quite low by base-metal standards and some companies have installed flotation cells in their beneficiating plants to complement gravity separation and improve the recovery of tin and other metals. Fuming processes, which can recover tin as tin oxide from slags, residues, low-grade concentrates and even directly from ores, are being used increasingly to improve overall tin recovery. The impure oxide is converted to metal in conventional smelters.

## USES

The major use of tin is in tinplate and tinning, which account for over 40 per cent of the world's consumption. The manufacture of solders is the second-largest use of tin, accounting for just over one-quarter of the world's total. Tin is also used in the manufacture of babbit, bronze and brass alloys, pewter, and a wide range of tin chemicals.

Tin use in tinplate generally remained flat over the past few years in most industrial countries or has declined. In the United States, tinplate consumption has fallen as aluminum almost totally replaced tinplate in the large beverage can market, but there has so far been relatively little penetration of aluminum into the food can market. For the remaining market, tin is being used more efficiently as tin used in tinplating declined from about 5½ t per thousand t of steel in the mid-1960s to about 4 t in 1982. Tinplate consumption has remained relatively stable in western Europe and Japan, where there has been only limited penetration by aluminum into can markets. Moreover, tin used per thousand t of steel in tinplate is higher in both these markets, at about 5 t and over 6 t, respectively. Both regions are also significant exporters of tinplate, but the growing production of tinplate in developing countries is likely to curtail this trade in the future.

The solder and bronze/brass markets, other important uses for tin, are both relatively mature. In solder uses, the strong growth in electronics applications is partially tempered by increasing miniaturization, which reduces the amount of solder used per unit. However, the electronics component market is growing rapidly, and tin consumption should also follow this trend. The use of solders in automobile production is declining as alternative materials and fabricating techniques are introduced. Any large-scale substitution of aluminum for copper radiators would significantly reduce solder and therefore tin use. Bronze, brass and other tin-containing alloys are widely used in construction, machinery and equipment and consumer durables. Growth in these applications has tended to be relatively slow and some are vulnerable to substitution, for example by plastics in plumbing and aluminum in refrigeration and air conditioning.

Tin consumption prospects are more promising in a wide range of chemical, including agricultural, applications. While no particular developments stand out as individually larger tin users, future market growth in this area is likely to be stronger than in the traditional tinplate and other alloy applications. Organotin chemicals in particular have a wide range of applications in wood preservatives, anti-fouling paints, plastics and crop protection.

The International Tin Research Council, which is the only major organization conducting research and development on tin applications and promoting the use of tin, celebrated its 50th anniversary in 1982. Its headquarters and research facilities are on the outskirts of London, England, and Tin Information Centres are located in Australia, Belgium, West Germany, Japan and United States, with part-time representatives in Brazil, Italy and the Netherlands. Funding is contributed by the governments of Indonesia, Malaysia, Nigeria, Thailand and Zaire. Bolivia was a member until 1981, and Australian tin producing companies contribute voluntarily.

## PRICING MECHANISMS AND TARIFFS

The principal tin markets are centred on the Kuala Lumpur market in Malaysia and the London Metal Exchange, which trades in both cash (spot) metal and three months future contracts. In October 1984, the traditional market in Penang was replaced by the Kuala Lumpur market, which still trades only in cash (spot) metal. It is less restrictive than the Penang market, where prices were fixed jointly by the two main smelters. Its workings are based on those of the London Exchange.

The tariffs of Canada and the United States are listed in the Tariff table. Neither has tariffs on tin ores, concentrates or wrought tin, and both agreed during the Tokyo Round of GATT to reduce MFN rates on tin-containing manufactures over an eight-year period beginning in 1980. Tariffs levied by the European Economic Community and Japan are broadly similar to those of the United States, being free for ore, concentrates and unwrought metal from all sources and mostly between 4 and 8 per cent on tin products (MFN), but free from developing countries.

## OUTLOOK

World tin consumption, as defined in Table 4, peaked in 1973 at 214 900 t, a level that has never since been matched. Rising tin prices during the 1970s encouraged efforts to find substitutes and it is only in the developing countries, where the use of tinplate for containers is rising, that growth has been at all consistent. Rising tin prices were attributed to cost pressures (energy, equipment, etc.) and generally falling ore grades. Higher prices have encouraged greater interest in tin exploration, but this was initially slow to impact on tin supply. Unfortunately, it occurred at a time when world consumption would accelerate its fall. From 1979, world production exceeded consumption, and this gap widened until 1982, when export controls were implemented. Excess inventories should now decline slowly, but export controls are likely to be necessary for several more years.

Since 1982 and 1983, when it bottomed out, tin consumption should be able to increase very slowly during the remainder of the 1980s. Growth in tinplate production and consumption in developing countries will perhaps be able to compensate for the progressive decline that will continue to be felt in industrialized countries. On the solder market, the heavy growth of electronics applications should more than compensate for the miniaturization, and by 1987 will show an 8 000 t net increase over the 1983 figure for tin consumption in this sector. Tin consumption for the tinning of wires and electronics components and for chemicals should also increase from 5 000 to 6 000 t by 1987. Tin consumption is therefore expected to reach 167 000 t by 1987.

In the same period, prices could show a slight nominal increase, but the large remaining inventories will probably force the real price downward each year. A real increase in prices would probably harm the competitive position of tin at a time of growing substitution away from tin for its major use on traditional markets. By the end of 1985, discussions should begin on a Seventh International Tin Agreement. Current difficulties on the markets and the fact that the Sixth ITA will probably never be fully implemented appear to indicate that negotiations may be complicated and difficult.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| **CANADA** | | | | | |
| 32900-1 | Tin in ores and concentrates | free | free | free | free |
| 33507-1 | Tin oxides | free | 13.8 | 25 | free |
| 33910-1 | Collapsible tubes of tin or lead coated with tin | 10 | 13.9 | 30 | free |
| 34200-1 | Phosphor tin | 5 | 6.5 | 10 | 4.0 |
| 34300-1 | Tin in blocks, pigs, bars or granual form | free | free | free | free |
| 34400-1 | Tin strip waste and tin foil | free | free | free | free |
| 38203-1 | Sheet or strip, iron or steel, corrugated or not, coated with tin | 10 | 11.0 | 25 | 7.0 |
| 43220-1 | Manufacturers of tin plate | 14.8 | 13.9 | 30 | 9.0 |

| MFN: Reductions under GATT (effective January 1 or year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 33507-1 | 13.8 | 13.4 | 13.1 | 12.8 | 12.5 |
| 33910-1 | 13.9 | 12.9 | 12.0 | 11.1 | 10.2 |
| 34200-1 | 6.5 | 6.3 | 6.0 | 5.8 | 5.5 |
| 38203-1 | 11.0 | 10.3 | 9.5 | 8.8 | 8.0 |
| 43220-1 | 13.9 | 12.9 | 12.0 | 11.1 | 10.2 |

UNITED STATES (MFN)

| | | |
|---|---|---|
| 601.48 | Tin ore and black oxide in tin | free |
| 622.02 | Unwrought tin other than alloys of tin | free |
| 622.04 | Unwrought tin, alloys of tin | free |
| 622.06 | Unwrought tin, other | free |
| 622.10 | Tin waste and scrap | free |

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| 622.15 | Tin plates, sheets and strips, not clad | 4.2 | 3.8 | 3.3 | 2.9 | 2.4 |
| 622.17 | Tin plates, sheets and strips, clad | 8.4 | 7.5 | 6.6 | 5.7 | 4.8 |
| 622.20 | Tin wire, not coated or plated with metal | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 |
| 622.22 | Tin wire, coated or plated with metal | 5.1 | 4.9 | 4.7 | 4.4 | 4.2 |
| 622.25 | Tin bars, rods, angles shapes and sections | 5.1 | 4.9 | 4.7 | 4.4 | 4.2 |
| 622.35 | Tin powder and flakes | 5.1 | 4.9 | 4.7 | 4.4 | 4.2 |
| 622.40 | Tin pipes, tubes and blanks | 4.2 | 3.8 | 3.3 | 2.9 | 2.4 |
| 644.15 | Tin foil | 12.3 | 10.9 | 9.6 | 8.3 | 7.0 |

Sources: The Customs Tariff and Commodities Index, 1982, Revenue Canada; Tariff Schedules of the United States Annotated 1982, USITC Publication 1200; U.S. Federal Register, Vol.44, No. 241.

TABLE 1. CANADA, TIN PRODUCTION, IMPORTS AND CONSUMPTION, 1982-84

| | 1982 | | 1983P | | 1984 | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($) | (tonnes) | ($) | (tonnes) | ($) |
| **Production** | | | | | | |
| Tin content of tin concentrates and lead-tin alloys | 135 | 1,915,000 | 140 | 2,013,010 | 217$^{e}$ | 2,997,972$^{e}$ |
| **Imports** | | | | | | (Jan.-Sept.) |
| Blocks, pigs, bars | | | | | | |
| United States | 1 920 | 33,200,000 | 1 393 | 21,324,000 | 1 348 | 21,216,000 |
| Brazil | 602 | 9,939,000 | 980 | 15,933,000 | 508 | 8,371,000 |
| Bolivia | 451 | 6,993,000 | 798 | 13,028,000 | 334 | 5,468,000 |
| Malaysia | - | - | 240 | 4,068,000 | 360 | 5,966,000 |
| Belgium-Luxembourg | 210 | 3,522,000 | 160 | 2,611,000 | 65 | 1,069,000 |
| Other countries | 52 | 901,000 | 178 | 2,270,000 | 564 | 8,352,000 |
| Total | 3 235 | 54,555,000 | 3 749 | 59,234,000 | 3 179 | 50,442,000 |
| Tinplate | | | | | | |
| United States | 2 049 | 2,002,000 | 1 899 | 1,906,000 | 2 010 | 1,818,000 |
| West Germany | 2 295 | 1,882,000 | 298 | 239,000 | - | - |
| United Kingdom | 43 | 75,000 | 3 | 3,000 | - | - |
| Total | 4 387 | 3,959,000 | 2 200 | 2,148,000 | 2 010 | 1,818,000 |
| Tin, fabricated materials, nes | | | | | | |
| United States | 294 | 1,137,000 | 320 | 1,432,000 | 196 | 1,012,000 |
| West Germany | 2 | 11,000 | 9 | 58,000 | 3 | 17,000 |
| United Kingdom | 7 | 42,000 | 7 | 49,000 | 14 | 70,000 |
| Other countries | 4 | 21,000 | 13 | 48,000 | 7 | 32,000 |
| Total | 307 | 1,211,000 | 349 | 1,587,000 | 220 | 1,131,000 |
| **Exports** | | | | | | |
| Tin in ores, concentrates and scrap[1] | | | | | | |
| United Kingdom | 16 | 5,000 | 272 | 1,647,000 | 231 | 1,211,000 |
| United States | 386 | 959,000 | 49 | 262,000 | 19 | 108,000 |
| Spain | 68 | 452,000 | 52 | 225,000 | - | - |
| U.S.S.R. | 46 | 672,000 | - | - | - | - |
| Other countries | 85 | 602,000 | - | - | - | - |
| Total | 601 | 2,690,000 | 373 | 2,134,000 | 250 | 1,319,000 |
| Tinplate scrap | | | | | | |
| United States | 2 145 | 222,000 | 4 984 | 226,000 | 3 204 | 137,000 |
| Indonesia | - | - | 305 | 125,000 | - | - |
| Italy | - | - | 94 | 38,000 | - | - |
| Taiwan | - | - | 34 | 13,000 | 36 | 9,000 |
| Other countries | 105 | 22,000 | - | - | - | |
| Total | 2 250 | 244,000 | 5 417 | 402,000 | 3 240 | 146,000 |
| **Consumption** | | | | | | |
| Tinplate and tinning | 2 034 | .. | 2 049 | .. | | |
| Solder | 1 212 | .. | 1 059 | .. | | |
| Babbit | 131 | .. | 174 | .. | | |
| Bronze | 37 | .. | 60 | .. | | |
| Other uses (including collapsible containers, foil, etc.) | 114 | .. | 73 | .. | | |
| Total | 3 528 | .. | 3 415 | .. | | |

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Tin content of ores and concentrates plus gross weight of tin scrap.

P Preliminary; .. Not available; - Nil; $^{e}$ Estimate.

TABLE 2. CANADA, TIN PRODUCTION, EXPORTS, IMPORTS AND CONSUMPTION, 1970, 1975 AND 1979-84

| | Production[1] | Exports[2] | Imports[3] | Consumption[4] |
|---|---|---|---|---|
| | | (tonnes) | | |
| 1970 | 120 | 268 | 5 111 | 4 565 |
| 1975 | 319 | 1 052 | 4 487 | 4 315 |
| 1979 | 337 | 712 | 4 689 | 4 675 |
| 1980 | 243 | 883r | 4 527 | 4 517 |
| 1981 | 239 | 513 | 3 791 | 3 766 |
| 1982 | 135 | 601 | 3 235 | 3 528 |
| 1983P | 140 | 373 | 3 749 | 3 415 |
| 1984P | 217 | 250[5] | 3 179[5] | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Tin content of tin concentrates shipped plus tin content of lead-tin alloys produced. [2] Tin in ores and concentrates and tin scrap, and re-exported primary tin. [3] Tin metal.
[4] Current coverage exceeds 90 per cent, whereas until 1972, coverage was in the order of 80 to 85 per cent. [5] Jan.-Sept. only.
P Preliminary; r Revised.

TABLE 3. WORLD[1] TIN PRODUCTION, CONSUMPTION AND PRICES, 1970 TO 1984

| | Production | | | Prices | |
|---|---|---|---|---|---|
| | Tin in Conc. | Primary Metal | Consumption | Malaysia[2] | NY Dealer[3] |
| | | | (000 t) | | |
| 1970 | 185 | 185 | 185 | 10.99 | 1.74 |
| 1971 | 188 | 187 | 189 | 10.44 | 1.67 |
| 1972 | 196 | 191 | 192 | 10.36 | 1.77 |
| 1973 | 189 | 188 | 215 | 11.35 | 2.27 |
| 1974 | 184 | 182 | 200 | 18.79 | 3.96 |
| 1975 | 181 | 179 | 173 | 15.94 | 3.40 |
| 1976 | 180 | 183 | 194 | 18.96 | 3.75 |
| 1977 | 188 | 180 | 185 | 26.26 | 5.33 |
| 1978 | 197 | 194 | 185 | 28.82 | 5.89 |
| 1979 | 200 | 201 | 186 | 32.42 | 7.07 |
| 1980 | 201 | 198 | 174 | 35.72 | 7.86 |
| 1981 | 205 | 197 | 163 | 32.34 | 6.80 |
| 1982 | 190 | 180 | 157 | 30.09 | 6.20 |
| 1983 | 172 | 159 | 155 | 30.19 | 6.17 |
| 1984e | 164 | 151 | 161 | 29.16 | 5.90 |

Source: International Tin Council.
[1] Coverage is the same as in Tables 4 and 5. [2] Cash price ex-smelter for Grade A tin, shipment within 60 days, in Malaysian ringgits per kg, the ringgit being the unit used to define price levels under successive International Tin Agreements. [3] Median of prices for Grade A tin, in U.S. dollars per pound, ex-dock New York, submitted by participating dealers for delivery within seven business days.
e Estimate.

### TABLE 4. WORLD[1] CONSUMPTION OF PRIMARY[2] TIN, 1970, 1982, 1983 AND 1984

| | 1970 | 1982 | 1983 | 1984e |
|---|---|---|---|---|
| | | (tonnes) | | |
| EEC, total[3] | 58 246 | 39 936 | 38 214 | 38 500 |
| West Germany | 14 062 | 13 163 | 13 792 | 15 100 |
| France | 10 500 | 8 187 | 7 564 | 7 800 |
| United Kingdom | 16 951 | 6 979 | 6 123 | 4 600 |
| Netherlands | 5 467 | 5 142 | 4 400 | 5 000 |
| Italy | 7 200 | 4 200 | 4 200 | 4 400 |
| Belgium/Luxembourg | 3 000 | 1 889 | 1 804 | 1 600 |
| United States | 53 807 | 33 000 | 34 300 | 34 900 |
| Japan | 24 710 | 28 707 | 30 504 | 32 400 |
| Spain | 3 040 | 4 400 | 4 400 | 4 400 |
| Poland | .. | 4 575 | 4 351 | 4 300 |
| Brazil | 2 139 | 4 953 | 3 942 | .. |
| Canada | 4 640 | 3 400 | 3 776 | 4 000 |
| Czechoslovakia | 3 420 | 3 500 | 3 550 | 3 500 |
| Republic of Korea | 394 | 2 093 | 2 628 | .. |
| Australia | 3 837 | 2 700 | 2 500 | 2 500 |
| Total, incl. Others | 184 800 | 153 500 | 154 700 | 160 800 |

Source: International Tin Council.
[1] Excludes countries with centrally planned economies, except Bulgaria, Czechoslovakia, Hungary, Poland, Romania and Yugoslavia. [2] May include secondary tin in some countries. [3] Includes all 1982 members in all years except Greece in 1970.
.. Not available; e Estimate.

### TABLE 5. WORLD[1] PRODUCTION OF TIN-IN-CONCENTRATES, 1970, 1982, 1983 AND 1984

| | 1970 | 1982 | 1983 | 1984e |
|---|---|---|---|---|
| | | (tonnes) | | |
| Malaysia | 73 794 | 52 342 | 41 367 | 39 000 |
| Indonesia | 19 092 | 33 800 | 26 554 | 23 300 |
| Bolivia | 30 100 | 26 773 | 24 736 | 20 000 |
| Thailand | 21 779 | 26 207 | 19 942 | 22 100 |
| Brazil | 3 610 | 8 218 | 13 083 | 17 700 |
| Australia | 8 828 | 12 615 | 9 578 | 8 600 |
| United Kingdom | 1 722 | 4 175 | 4 067 | 4 900 |
| South Africa | 1 986 | 3 035 | 2 668 | .. |
| Peru | 20 | 1 700 | 2 200 | .. |
| Zaire | 6 458 | 2 174 | 2 004 | 2 300 |
| Total, incl. Others | 184 900 | 190 500 | 171 700 | 164 300 |

Source: International Tin Council.
[1] Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary.
.. Not available; e Estimate.

### TABLE 6. WORLD[1] PRODUCTION OF PRIMARY TIN METAL, 1970, 1982, 1983 AND 1984

| | 1970 | 1982 | 1983 | 1984$^e$ |
|---|---|---|---|---|
| | (tonnes) | | | |
| Malaysia | 91 945 | 62 836 | 53 338 | 44 800 |
| Indonesia | 5 190 | 29 755 | 28 390 | 22 800 |
| Thailand | 22 040 | 25 479 | 18 467 | 18 900 |
| Bolivia | 300 | 18 980 | 14 293 | 12 000 |
| Brazil | 3 100 | 9 297 | 12 560 | 16 900 |
| United Kingdom | 22 035 | 8 164 | 6 498 | 6 600 |
| Netherlands | 5 937 | 2 757 | 3 650 | 7 100 |
| Australia | 5 211 | 3 105 | 2 878 | 2 800 |
| Spain | 3 908 | 2 750 | 2 783 | 3 000 |
| United States | 4 540 | 3 500 | 2 500 | 3 500 |
| South Africa | 1 491 | 2 197 | 2 200 | .. |
| Singapore | .. | 4 000 | 1 800 | .. |
| Nigeria | 8 069 | 1 691 | 1 400 | 1 300 |
| Total, incl. Others | 184 900 | 180 000 | 158 800 | 151 000 |

Sources: International Tin Council.

[1] Excludes countries with centrally planned economies, except Czechoslavakia, Poland and Hungary.

.. Not available; e estimate.

### TABLE 7. MONTHLY AVERAGE TIN PRICES[1], 1983 AND 1984

| | Canada Cdn ¢/lb | | Dealer NY US ¢/lb | | London Metals Exch. US Equiv. ¢/lb | | Malaysia US Equiv. ¢/lb | |
|---|---|---|---|---|---|---|---|---|
| | 1983 | 1984 | 1983 | 1984 | 1983 | 1984 | 1983 | 1984 |
| January | 772.78 | 791.01 | 553.43 | 569.05 | 547.86 | 549.50 | 579.80 | 565.12 |
| February | 801.37 | 794.44 | 600.53 | 574.81 | 591.09 | 557.64 | 585.52 | 566.54 |
| March | 818.87 | 807.69 | 619.57 | 581.68 | 609.19 | 562.57 | 598.60 | 576.83 |
| April | 847.93 | 817.15 | 633.86 | 584.19 | 625.37 | 564.34 | 620.41 | 577.66 |
| May | 835.86 | 839.03 | 620.43 | 586.00 | 613.23 | 570.55 | 612.95 | 573.92 |
| June | 824.76 | 842.28 | 613.91 | 588.33 | 605.56 | 574.20 | 600.67 | 574.01 |
| July | 812.92 | 845.83 | 609.85 | 574.81 | 598.31 | 564.00 | 593.89 | 565.42 |
| August | 799.97 | 828.78 | 593.74 | 565.94 | 581.14 | 557.86 | 583.84 | 566.87 |
| September | 797.48 | 823.50 | 593.62 | 555.68 | 578.43 | 548.28 | 580.00 | 562.60 |
| October | 796.99 | 807.87 | 596.00 | 540.05 | 578.20 | 532.53 | 580.94 | 551.02 |
| November | 814.46 | 815.73 | 602.32 | 553.00 | 579.19 | 543.79 | 583.85 | 551.87 |
| December | 799.77 | 803.15 | 578.14 | 540.00 | 559.81 | 531.61 | 569.00 | 547.49 |
| Yearly Average | 810.26 | 818.04 | 601.28 | 567.80 | 589.19 | 556.55 | 590.79 | 564.95 |

Sources: Metals Week; US General Services Administration; Northern Miner.

[1] Prices are for Grade A (in the U.S.) or High Grade - 99.85 per cent tin or more - except the LME price which is for Standard Grade - 99.75 per cent tin or more.

# Titanium and Titanium Dioxide

D.E.C. KING

## CANADA

Canadian industries based on titanium, include ilmenite mining and smelting, titanium oxide and pigment production, titanium metal fabrication to finished parts, coating of welding rods, and the manufacture of titanium carbide and nitride coated parts. Also, titanium-bearing master alloys are incorporated into special steel and aluminum alloys. The mining, smelting and pigment operations are carried out exclusively in Quebec, whereas the downstream activities are located in several provinces. Canada does not have any capacity for producing primary titanium (in the form of sponge or granules), ferrotitanium, or for vacuum melting of primary titanium to produce billets, although Atlas Steels division of Rio Algom Limited has facilities at Welland, Ontario, to custom forge and roll billets.

QIT - Fer et Titane Inc. (QIT) is the only company that mines titanium ore in Canada. Ilmenite, a mineral containing somewhat more iron than titanium, is mined at Havre St. Pierre, Quebec. The raw ore is shipped to Tracy, Quebec, where it is beneficiated, and the concentrate smelted to produce high quality pig iron and titania ($TiO_2$) slag (Sorelslag). QIT completed a $9.4 million expansion to its beneficiation plant during 1983, enabling a further removal of gangue material by dry magnetic separation. By smelting the improved concentrate (96 per cent ilmenite content compared with the former 92-93 per cent content) to a greater degree of reduction, the company has been able to produce Sorelslag containing about 80 per cent $TiO_2$ compared with the 70-72 per cent $TiO_2$ slag previously marketed. This operating mode has reduced furnace operating capacity to some degree, but except for this limitation QIT has been able to operate at full capacity in response to the recovery in the market for slag, particularly in the second half of 1984.

QIT in late-1984 announced plans for a $150 million capital investment at its Tracy operation. The electric furnaces will be up-graded and basic oxygen furnaces added, so that liquid iron from the electric furnaces can be further blown to produce steel. Of the 400 000 t of steel capacity in the new mode of operation, expected to start in 1986, a part will be used to produce steel powder. QIT already produces and markets Atomet iron powder at the plant. The rated capacity of the modified plant will be 850 000 tpy of 80 per cent $TiO_2$ Sorelslag.

Most of QIT's output of Sorelslag is exported to the United States and Europe, while approximately 10 to 15 per cent is sold in Canada to two pigment producers, NL Chem Canada Inc. and Tioxide Canada Inc. Both pigment producers employ the sulphate process.

In 1984, both Canadian pigment producers were operating at their full capacity of about 36 000 tpy of $TiO_2$ pigment each. Tioxide lost production for a period of several weeks in the second half of 1984 when the plant was shut down because of a strike during negotiations for a collective agreement. The labour contract at NL Chem expires in June of 1985. Pigment exports to the United States amounted to over 25 per cent of Canadian production, which helped the Canadian producers while the demand in Canada lagged behind the buoyant U.S. pigment market. However, Canadian imports of $TiO_2$ pigment from the United States and Europe offset approximately one half of Canadian exports. Both companies purchase sulphuric acid at prices which reflect the present escalating price of elemental sulphur. NL Chem buys elemental sulphur to produce about 60 per cent of its acid requirement.

Tioxide was negotiating with Federal and Provincial departments for approval to construct a new sulphate pigment plant adjacent to its existing plant.

A small number of Canadian companies which make finished products from titanium forgings, castings, bar, pipe, tube, plate

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and sheet. Walbar of Canada Inc. of Toronto, Ontario and Pratt and Whitney Aircraft of Canada Ltd. of Longueuil, Quebec, machine forgings, investment castings, and bar stock to produce parts for turbine engines. The shop scrap is sold to U.S. producers offerrotitanium and briquettes which are made from Titanium scrap and offgrade sponge. The total amount of titanium forgings, castings and bar stock consumed by these two companies in 1984 was of the order of 240 t.

Titanium Ltée of St. Laurent, Quebec and Ellett Copper and Brass Co. Ltd. of Port Coquitlam, British Columbia custom produce titanium tanks, pressure vessels, heat exchangers, fans, and other equipment for pulp, chemical, petrochemical and metallurgical industries.

The aircraft companies de Havilland Aircraft of Canada Ltd., Downsview, Ontario, Canadair Ltd, Montreal, Quebec, and McDonnell Douglas Canada Ltd., Malton, Ontario, produce airframe parts, such as firewalls, motor mounts, nacelles and wings. The quantities of titanium used in making chemical equipment and airframes in Canada vary widely, but appear to be of the order of 50 to 125 tpy for chemical equipment and 10 to 30 tpy for airframes.

The quantities of titanium added as ferrotitanium and composite master alloys to specific grades of steels are small compared with other alloying elements. They nevertheless accounted for an estimated 150 to 190 t of contained titanium in 1984. Used as an alloying agent, titanium is beneficial in controlling nitrogen and acts as a grain refiner in high-strength, low-alloy steel plate; it is also used as a carbide stabilizer in type 409 stainless steel. By comparison, the quantities of titanium added to aluminum alloys are of a much smaller order, possibly about 10 tpy of titanium in 5-10 per cent titanium-aluminum master alloys.

The quantities of titanium used by Canadian companies producing wear resistant parts for the mining and other industries are very small and are not separately reported in statistics. Titanium is used in mixed carbides with tungsten, and in titanium nitride coatings. Canadian companies producing carbides and nitrides include Kennametal Ltd. Canadian General Electric Ltd., and Valenite Modco Ltd.

## WORLD DEVELOPMENTS

### Titanium Minerals

Ilmenite is the source for 90 per cent of the world supply of titanium dioxide pigment production. The more expensive rutile ($TiO_2$) is favoured by producers of primary titanium metal. Anatase ($TiO_2$) deposits of Brazil are also potentially important. Two other raw materials, titaniferous slag and synthetic rutile produced from ilmenite, are used extensively. The relative scarcity and high cost of rutile supplies are creating an increasing demand for beneficiated ilmenite, although in the past rutile producers have tended to curb competition from beneficiates by cutting the price of rutile. There was by the end of 1984 an incipient world shortage of titanium raw materials although ore reserves were generally abundant. Accordingly, the following increases in capacity were in progress:

**Australia:** Consolidated Rutile will double its rutile and zircon production capacity to 80 000 tpy for each mineral, by installing a new dredge. By early-1985, it will also add a further 15 000 tpy capacity by purchasing the dredge now operated by Associated Minerals Consolidated (AMC). AMC has reported that it may proceed with plans to install a synthetic rutile plant to produceabout 60 000 tpy, and Westralian Sands Ltd. has similar plans. Allied Aneabba's 1983 and 1984 outputs were lower than 1982 due to mining problems, but are expected to approach 1982 levels again in 1985.

Ilmenite production by Allied Aneabba, Westralian, AMC and Cable has been running close to capacity.

**Sierra Leone:** Sierra Rutile Ltd. produced nearly 72 000 t of rutile in 1983, the largest output of any single mine. The company resumed production in January 1983 after Nord Resources Corp. of Dayton, Ohio acquired an 85 per cent interest in it. Assuming continued strong demand, production Sierra expects to build up to nearly its full capacity of 100 000 t in 1985.

**Brazil:** The Companhia Vale do Rio Doce (CVRD) intends to go ahead with a 180 000 tpy plant at Tapira at a cost of $200 million to produce a 90 per cent $TiO_2$ concentrate from anatase ore. CVRD had built a pilot concentrator and has been testing the circuit since late-1983. Engineering for the new plant is expected to be finalized in two years time.

**Norway:** Supported by the Norwegian government Kronos Titan A/S, a subsidiary of NL Industries Inc., is installing an ilmenite smelting process which is expected to go on-stream at Tyssedal in 1986 with a capacity of 200 000 tpy of 75 per cent $TiO_2$ slag.

**India:** India Rare Earths Ltd. is expected to produce some synthetic rutile in 1985 from a plant being constructed at Orissa. No further information was available on an announcement by Kerala Minerals Ltd. to build a new rutile plant.

**United States:** Kerr McGee has scheduled the start-up of a new synthetic rutile plant at Mobile in 1985.

### Titanium Dioxide Pigment

The consumption of pigment has recovered from the recession of 1982 and is expected to remain strong throughout 1985. While the long-term growth in demand by the mature markets of North America and western Europe is estimated to be in the range of 1 to 2 per cent per year, worldwide demand should grow at a rate of 2.5 to 3.0 per cent per year, being influenced by greater growth rates in the less developed regions of South America and Asia. The approximate worldwide distribution of titanium pigment usage (60 per cent in paint, 13 per cent in paper, and 15 per cent in plastics with the remainder spread more or less evenly between, rubber, ink, textiles and ceramics), is somewhat distorted by North America's higher usage in paper (20 per cent).

There has recently been a considerable corporate re-structuring of the pigment industry involving acquisitions of existing plants. However, virtually no overall new capacity has been added. Because of this and the fact that existing facilities are operating at or near full capacity, a strong upward pressure on prices may be anticipated for several years, if demand remains firm. Total world titanium pigment capacity in 1983 was about 2.5 million t of which the United States had about 32 per cent, other western countries about 47 per cent, Japan 9 per cent and communist countries 12 per cent.

In recent years, environmental regulations have been a major consideration in the closure of several sulphate plants and the lost capacity has been replaced by chloride plants. Both processes produce volumes of effluent which are indirectly proportional to the grade of feedstock. Hence, rutile, high-grade slag, and beneficiated ilmenite produce less effluent and, except for price, would normally be preferred to ilmenite. In the chloride process the chlorine reagent is recycled and the economy so achieved enables the use of higher-grade feedstock than in the sulphate process.

Operating costs in the chloride process are roughly in the proportions 40 per cent fixed costs, 40 per cent variable costs, 10 per cent laboratory and 10 per cent plant materials. The largest variable cost is in raw materials, but the biggest unit operating cost is in "finishing", which involve re-slurrying and re-drying in order to coat the pigment particles with compounds which reduce the absorption of ultraviolet light, which would otherwise break down the organic paint base.

Apart from raw materials, a large component of sulphate process operating cost is the cost of sulphuric acid. Fossil fuel energy is the next largest cost component. While fuel costs are currently fairly stable, the price of acid is escalating partly because of the weakness in base-metals production.

Europe still has some excess pigment capacity, and has become very competitive in North America because of the relative weakness of European currencies against the dollar.

### Titanium Metal

World consumption increased in the late-1970s and reached an all-time peak of 51 412 tpy in 1981. This rapid growth stimulated increases in production capacity, which in 1983 totalled about 68 000 tpy of primary titanium in the market economies, including about 33 400 tpy in the United States, 36 600 tpy in Japan where the greatest expansions took place, and 5 000 tpy in the United Kingdom. However, the USSR has the world's largest production capacity, estimated at 42 000 tpy by the U.S. Bureau of Mines and 57 000 to 60 000 tpy by Wogen Resources Ltd. China's capacity was estimated at 3 500 tpy.

The western world capacity for melting, semi-fabricating, and casting amounted to a total of 65 000 tpy in 1983, including 45 000 tpy in the United States, 13 000 tpy in Japan, 5 000 tpy in the United Kingdom, 2 000 tpy in West Germany and 1 000 tpy in France.

Western world consumption slumped after 1981 under the influence of the recession, reaching a low in the United States of 17 600 t in 1983 but recovering to an estimated 20 000 t in 1984. About 45 per cent of titanium consumed in the United States in 1983 (excluding alloying) went to military applications, 34 per cent to commercial aircraft and 21 per cent to industrial applications. Japan's consumption depends far less on the volatile military market; less than 10 per cent is used in aerospace applications and more than 90 per cent in industrial applications. In western Europe, industrial applications account for 40 to 50 per cent of consumption.

The main loss of demand in 1982-83 was caused by a fall in demand in the civilian and military aircraft industries. A recovery in the demand for civil aircraft and industrial products was the main element in market strength in 1984, which is forecast by several sources to continue into 1985 with a gain in consumption of about 15 per cent over 1984. Average growth of about 10 per cent per annum is forcast for the next 3 years during which time the military market is expected to play a reduced role.

The United States General Service Administration (GSA) let contracts for the purchase of 4 500 t of titanium sponge in 1983-84. Dumping penalties were charged against Japanese sponge suppliers in connection with their participation in this purchase. This action has lead to complaints, by non-integrated producers which depended on Japanese sponge and a claim that U.S. integrated producers can now control domestic supply.

A new process for producing titanium sponge and powder will be pilot tested by Albany Titanium Inc. in two pilot plants now under construction, one a 2,000 lbs per month titanium powder plant already under test and the other a 2,000 lbs per month titanium sponge plant due to start in February or March 1985. Both units employ a patented technology for the continuous reduction of ilmenite by zinc and aluminum, following a pretreatment in which the ilmenite is briquetted with other compounds. Albany claims that the process is low cost and the end product of high purity. Plans for a 5 000 tpy plant are well advanced and start-up is forecast for the summer of 1986.

A joint venture between Martin Marietta Corp. and Nippon Kokan to produce fabricated titanium products, was announced during 1984. The new corporation International Light Metals Inc. plans to establish its operations near the MMC plant at Torrance, California.

The Titanium Development Association of Dayton, Ohio, was formed in 1983 to improve communications between North American producers and consumers and held its first annual meeting in November 1984. A monthly newsletter has been started and a 1985 Buyers' Guide completed. Periodic distribution of titanium industry statistics is planned.

## PRICES

Prices of mill products fell in 1982-83 and, expressed in constant dollars, were in 1984 about 30 per cent less than 1981 prices. However, titanium sponge prices did not fall to the same extent. An overall lowering of titanium prices would open the way to dramatically increased usage. In this regard, progress has been made, notably in Japan, towards more efficient and less costly processing. However, even at present prices, titanium is cheaper than special nickel alloys and its light-weight and high-corrosion resistance can often permit design economies in the thickness and weight of components.

The current excess of sponge capacity over consumption should eliminate erratic price movements for the next 5 years, with prices reacting normally to market demand. An increase in sponge price of about 15 to 20 per cent in 1985 appears likely.

## USES

Titanium metal usage is based on its relative abundance, unique physical properties and corrosion resistance. Initially, uses were found in military aircraft where cost was not the main factor, and its high-strength, lightness and high melting point, could be utilized for engine and airframe applications. Greater availability and lower prices have led to expanding usage in commercial and private aircraft. Specifications for aircraft quality are high, and since titanium has a strong tendency to combine with oxygen and nitrogen, melting has to be carried out in vacuum, sometimes twice or three times before an ingot is produced for fabrication.

Commercial titanium produced to less demanding specifications, is used in industrial applications. Titanium's high corrosion resistance lends itself to a wide range of uses in the chemical, metallurgical and paper industries, power plants and desalination plants. In these applications about 50 per cent of the total quantity of titanium consumed is used in heat transfer and seawater cooling applications, about 25 per cent in chemical process equipment, and about 20 per cent as electrodes in electrolytic plants. However, a vast number of minor applications are developing, such as spectacle eye frames, camera parts, yacht rigging, and medical uses such as hip joints.

## OUTLOOK

Environmental regulations will probably continue to favour the chloride process in new pigment plants. Although fluid-bed roasting is a standard way of oxidizing titanium chloride in the chloride process, plasma oxidation such as is used by Tioxide UK might be favoured where electric power costs are low. Effluent treatment and disposal will require further development for both the chloride and sulphate processes.

In the production of titanium sponge, developments toward the use of less power is a trend exemplified by the new plant of Showa Titanium, Japan where power consumption is reportedly 15 000 to 18 000 kWh per ton instead of the 25 600 to 30 000 kWh per ton in most plants. Since existing sponge plants are based on batch operations, there are also considerable potential cost savings to be gained from the development of a continuous process.

The development of semi-fabrication to near-net-shape would eliminate much subsequent machining, particularly in the case of turbine blades which currently require the removal of up to 85 per cent of the initial forging weight.

Titanium turnings and cuttings are difficult to recycle for use in rotating jet engine parts. One of the main problems is the removal of tiny tungsten carbide particles which contaminate the scrap. Suisman Titanium Corp. in the United States has patented a process to remove high density contaminants, which would greatly enhance the value of the recycled titanium.

British Aerospace Plc. plans to increase the use of superplastic forming and diffusion bonding of titanium alloys for aircraft parts. While slow, the process reduces necking and local failures, and leaves the material with a fine uniform grain size and limited texturing.

A dramatic increase in the demand for titanium metal has been anticipated for some years. Such a development would likely occur if there was a major price breakthrough, which could happen if there was a significant lowering of production costs.

## TARIFFS

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| **CANADA** | | | | | |
| 32900-1 | Titanium ore | free | free | free | free |
| 34715-1 | Sponge and sponge briquettes, ingots, blooms, slabs, billets, and castings in the rough, of titanium or titanium alloys for use in Canadian manufactures (expires June 30, 1984) | free | free | 25 | free |
| 34735-1 | Tubing of titanium or titanium alloys for use in Canadian manufactures (expires June 30, 1984) | free | free | 25 | free |
| 34736-1 | Sheet, strip or plate of titanium or titanium alloys, cold-rolled, not more than 0.2015 inch in thickness, for use in the manufacture of tubes (expires June 30, 1984) | free | free | 25 | free |
| 34745-1 | Bars, rods, plate, sheet, strip, foil, wire, coated or not; forgings and mesh of titanium or titanium alloys, for use in Canadian manufactures (expires June 30, 1984) | 7.5 | 7.5 | 25 | 5 |
| 37506-1 | Ferrotitanium | free | 4.7 | 5 | free |
| 92825-1 | Titanium oxides | free | 11.3 | 25 | free |
| 93207-6 | Titanium whites, not including pure titanium dioxide | free | 11.3 | 25 | free |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 37506-1 | 4.7 | 4.5 | 4.3 | 4.2 | 4.0 |
| 92825-1 | 11.3 | 10.9 | 10.6 | 10.3 | 10.0 |
| 93207-6 | 11.3 | 10.9 | 10.6 | 10.3 | 10.0 |

| UNITED STATES (MFN) | | | | | | |
|---|---|---|---|---|---|---|
| 422.30 | Titanium compounds | 6.2 | 5.9 | 5.6 | 5.2 | 4.9 |
| 473.70 | Titanium dioxide | 6.8 | 6.6 | 6.4 | 6.2 | 6.0 |
| 601.51 | Titanium ore | Remains free | | | | |
| 606.46 | Ferrotitanium and ferro-silicon titanium | 4.6 | 4.4 | 4.1 | 3.9 | 3.7 |
| 629.12 | Titanium metal, waste and scrap | 12.6 | 11.3 | 9.9 | 8.6 | 7.2 |
| 629.14 | Titanium metal, unwrought | 17.0 | 16.5 | 16.0 | 15.5 | 15.0 |
| 629.20 | Titanium metal, wrought | 17.0 | 16.5 | 16.0 | 15.5 | 15.0 |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated (1983), USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, TITANIUM PRODUCTION AND TRADE, 1982-84

| | 1982P | | 1983P | | 1984 | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Production** (shipments) | | | | | | |
| Titanium dioxide, slag | x | x | x | x | | |
| **Imports** | | | | | | |
| Titanium in ores and concentrates | | | | | (Jan.-Oct. 1984) | |
| United States | | | | | 1 347 | 825 |
| Australia | | | | | 2 058 | 854 |
| South Africa | | | | | 36 | 2 |
| Total | | | | | 3 441 | 1,681 |
| Titanium dioxide, pure | | | | | | |
| United States | 3 344 | 6,470 | 7 101 | 12,641 | 6 956 | 12,444 |
| West Germany | 1 351 | 1,794 | 2 797 | 3,990 | 2 402 | 3,319 |
| Australia | 17 | 30 | 592 | 1,181 | 582 | 1,178 |
| France | 74 | 104 | 790 | 1,155 | 545 | 744 |
| Belgium-Luxembourg | 297 | 418 | 584 | 798 | 475 | 663 |
| United Kingdom | 182 | 281 | 321 | 458 | 581 | 803 |
| Spain | 438 | 753 | 278 | 296 | 240 | 299 |
| Other countries | 34 | 42 | 505 | 666 | 1 495 | 2,141 |
| Total | 5 737 | 9,892 | 12 968 | 21,185 | 13 276 | 21,591 |
| Titanium dioxide, extended | | | | | | |
| West Germany | - | - | 2 599 | 2,955 | 4 733 | 5,862 |
| United States | 135 | 340 | 611 | 1,186 | 865 | 1,820 |
| Belgium-Luxembourg | - | - | 481 | 832 | 94 | 140 |
| Spain | 163 | 284 | 454 | 646 | 249 | 402 |
| Other countries | 71 | 120 | 1 410 | 2,122 | 1 698 | 2,352 |
| Total | 369 | 744 | 5 555 | 7,741 | 7 639 | 10,576 |
| Titanium metal | | | | | | |
| United States | 389 | 15,881 | 227 | 8,903 | 197 | 6,017 |
| Belgium-Luxembourg | 3 | 321 | 5 | 624 | 5 | 398 |
| United Kingdom | 18 | 334 | 20 | 500 | 17 | 385 |
| Japan | 91 | 1,708 | 18 | 203 | 5 | 460 |
| Other countries | 3 | 188 | 5 | 413 | 59 | 1,307 |
| Total | 504 | 18,432 | 275 | 10,643 | 284 | 8,567 |
| Ferrotitanium[1] | | | | | | |
| United States | - | - | 14 | 39 | 10 | 32 |
| Belgium-Luxembourg | - | - | 5 | 28 | 28 | 126 |
| United Kingdom | - | - | 298 | 1,045 | 188 | 721 |
| Total | 110 | - | 317 | 1,112 | 226 | 879 |
| **Exports**[2] to the United States | | | | | | |
| Titanium metal, unwrought including waste and scrap | 211 | 1,364 | 415 | 2,342 | 5 | 62 |
| Titanium metal, wrought | 432 | 7,616 | 287 | 5,180 | 150 | 2,908 |
| Titanium dioxide | 19 880 | 25,135 | 23 190 | 27,396 | 21 427 | 26,467 |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Total alloy weight. [2] U.S. Department of Commerce, U.S. General Imports, Report F.T. 135. Canadian export statistics do not provide separate categories.
P Preliminary; - Nil; x Confidential.

## TABLE 2. CANADIAN TITANIUM PRODUCTION AND IMPORTS 1970, 1975, 1979-84

| | Production | | Imports | | |
|---|---|---|---|---|---|
| | Ilmenite[1] | Titanium Dioxide Slag[2] | Titanium Dioxide Pure | Titanium Dioxide Extended[3] | Total Titanium Dioxide Pigments |
| | | | (tonnes) | | |
| 1970 | 1 892 290 | 766 300 | 2 523 | 7 415 | 9 938 |
| 1975 | 1 543 480 | 749 840 | 2 467 | 241 | 2 708 |
| 1979 | 1 004 260 | 477 030 | 9 815 | 1 515 | 11 330 |
| 1980 | 1 853 270 | 874 710 | 6 135 | 148 | 6 283 |
| 1981 | 2 008 117 | 759 191 | 6 986 | 314 | 7 300 |
| 1982 | 1 735 000 | 669 000 | 5 737 | 369 | 6 106 |
| 1983 | x | x | 12 968 | 5 555 | 18 523 |
| 1984[4] | x | x | 13 276 | 7 639 | 20 915 |

Sources: Energy, Mines and Resources Canada; Statistics Canada; Company reports.
[1] Ore treated at Sorel; from company reports. [2] Slag with 70 to 72 per cent $TiO_2$; from company reports. [3] About 35 per cent $TiO_2$. [4] Jan.-Oct. 1984.
x Confidential.

## TABLE 3. PRODUCTION OF ILMENITE CONCENTRATE BY COUNTRIES, 1981-1983

| | 1981 | 1982P | 1983$^{e}$ |
|---|---|---|---|
| | | (000 tonnes) | |
| Australia | 1 337 | 1 179 | 1 134 |
| Canada[1] | 759 | 680 | 612 |
| Norway | 658 | 552 | 544 |
| U.S.S.R.$^{e}$ | 426 | 431 | 431 |
| Republic of South Africa | 370 | 381 | 363 |
| United States | 462 | 239 | W |
| India$^{e}$ | 189 | 190 | 181 |
| Finland | 159 | 160 | 154 |
| China | 136 | 136 | 136 |
| Malaysia | 145 | 121 | 109 |
| Sri Lanka | 80 | 80 | 73 |
| Other countries | 18 | 15 | 18 |
| Total | 4 739 | 4 164 | 3 755 |

Sources: U.S. Bureau of Mines, Minerals Yearbook Preprint, 1983; U.S. Bureau of Mines, Mineral Commodity Summaries, 1984.
[1] Titanium slag containing 70-71 per cent $TiO_2$.
P Preliminary; $^{e}$ Estimated; W withheld to avoid disclosing company proprietary data.

## TABLE 4. PRODUCTION OF RUTILE BY COUNTRIES, 1981-1983

| | 1981 | 1982P | 1983$^{e}$ |
|---|---|---|---|
| | | (000 tonnes) | |
| Australia | 229 | 220 | 218 |
| Sierra Leone | 51 | 48 | 72 |
| Republic of South Africa | 50 | 47 | 54 |
| United States | W | W | W |
| Sri Lanka | 13 | 13 | 14 |
| U.S.S.R.$^{e}$ | 9 | 9 | 9 |
| India$^{e}$ | 9 | 8 | 9 |
| Brazil | -- | -- | -- |
| Total | 361 | 345 | 376 |

Sources: U.S. Bureau of Mines, Minerals Yearbook Preprint, 1982; U.S. Bureau of Mines, Mineral Commodity Summaries, 1984.
P Preliminary; $^{e}$ Estimated; -- Amount too small to be expressed; W withheld to avoid disclosing company proprietary data.

TABLE 5. PRICES OF SELECTED TITANIUM COMMODITIES, 1982-84

| | 1982 | 1983 | 1984 |
|---|---|---|---|
| | | ($US) | |
| Titanium ore, fob cars Atlantic and Great Lake ports | | | |
| Rutile, 96%, per short ton, delivered within 12 months | 450.00-475.00 | 400.00-430.00 | 460.00-490.00 |
| Ilmenite, 54%, per long ton, shiploads | 70.00-75.00 | 70.00-75.00 | 70.00-75.00 |
| Slag, 70%, per long ton, fob Quebec | 150.00 | 150.00 | 155.00 |
| Titanium sponge, per lb | 5.56 | 5.56 | 5.55-5.85 |
| Mill products, per lb delivered | | | |
| Billet (Ti - 6AL-4V) | 15.00 | 15.00 | 8.01 |
| Bar (Ti - 6AL-4V) | 18.00 | 18.00 | 10.06 |
| Titanium dioxide, anatase[1], | | | |
| Bags, 20-ton lots, freight allowed, per lb | 0.69-0.70 | 0.69-0.70 | 0.69-0.70 |
| Titanium dioxide, rutile, regular grades, per lb | 0.75 | 0.75 | 0.75 |

Source: Metals Week, December.
[1] Chemical Marketing Report, December.
fob - Free on board.

# Tungsten

### D.R. PHILLIPS

## SUMMARY

The rebound of tungsten prices in 1984 from their historic low in 1983 led to a strengthening of the market and increased production by Canadian mines.

Canada's two producing tungsten mines, Canada Tungsten Mining Corporation Ltd. and Mount Pleasant Tungsten Mine reached near-capacity rates of operation in the first half of 1984. The opening of the latter in 1983 marks the beginning of a major new supplier to world markets of high-grade wolframite, in addition to the high-grade scheelite produced by Canada Tungsten.

## CANADIAN DEVELOPMENTS

Canada maintained its rank in fifth place of world shipments of tungsten ores and concentrates. However, 1983 producer shipments, estimated at 1 537 tonnes (t) tungsten trioxide ($WO_3$) content, were approximately 50 per cent less than 1982. Producer shipments for 1984 were estimated to exceed 1982 shipments of 3 029 t.

Canadian production of tungsten trioxide in 1984 was estimated at 465 300 tonne units (tu) compared to 41 399 tu in 1983 and to 358 300 tu in 1982. The decrease in 1983 is a result of the long closure at Canada Tungsten (Cantung) from January 22 to November 30, 1983 because of weak markets and continued low prices throughout the year. Cantung restarted its operation in December 1983 at half capacity and returned to full capacity in August of 1984. During the 1983 closure, programs were initiated to improve efficiencies, including high productivity mining methods, which resulted in a 20 per cent reduction in the work force on reopening.

Amax, through its wholly-owned subsidiary Amax North West Mining Company Ltd., continued to evaluate the Mactung scheelite deposit on the Yukon-Northwest Territories boundary. Development and production plans in 1983 had been temporarily delayed because of weakness of the market. The project is rescheduled to be completed in 1987.

Construction at the Mount Pleasant Tungsten mine/mill complex was completed in early 1983 and fine tuning of the 2 000 tpd mill operation was under way in late 1983. Mount Pleasant Tungsten Mine is a joint venture between Sullivan Mines Inc. (through its 89 per cent ownership of Brunswick Mines Ltd.) and Billiton Canada Ltd. The latter manages the mine and will market an estimated 1 000 t of $WO_3$ and 600 t of molybdenite ($MoS_2$) annually. Initially, the company will direct its attention to the production of tungsten, which will be marketed in the United States and Europe. Due to low prices and some technical problems, Mount Pleasant Tungsten reduced mining, beginning in October 1984, to 50 per cent of capacity. During the period of this reduction, the company will continue work on metallurgical improvements to increase recoveries.

Dimac Resources Corp., located in British Columbia, closed its 180 tpd mine/mill complex in 1982 because of poor market conditions and operational problems.

The resumption of production at Cantung and the opening of Mount Pleasant Tungsten in 1983 coincided with a major cyclical contraction in the consumption of tungsten. If the present economic recovery faulters, reductions in operations at Cantung and Mount Pleasant Tungsten could occur.

## INTERNATIONAL DEVELOPMENTS

World production of tungsten ores and concentrates in 1983 declined 19 per cent, to 38 320 t of contained tungsten, compared to 44 328 t in 1982. World production of ores and concentrates in 1984 was estimated to exceed 1982 production levels. Western world production declined in 1983 by approximately 17 per cent to 19 000 t of contained tungsten. Production in 1984 was estimated to be 25 000 t.

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At the end of 1983, all major North American mines, except Mount Pleasant Tungsten and Cantung, were closed or had plans to close. A modest recovery in tungsten prices in 1984 resulted in a return to higher production throughout the world. In the United States the Strawberry mine, operated by Teledyne Wah Chang, resumed production on a regular basis and produced close to record amounts in 1984. Union Carbide Corporation kept its Emerson mine closed throughout 1984 and operated its Pine Creek Bishop mine at approximately 50 per cent capacity on an intermittent basis. The Springer Mine, owned by the General Electric Company, remained closed throughout 1984.

The People's Republic of China (PRC) continued to be the world's largest producer, followed closely by the U.S.S.R. Tungsten production of the PRC decreased by 20 per cent in 1983 to an estimated 10 000 t, compared to a slight increase for the U.S.S.R. of 0.2 per cent. All other producing countries shared a decrease in production except Bolivia, which showed an increase of 18 per cent to approximately 3 000 t contained tungsten. Bolivia's plans to start-up its Anschutz mine in Chicote Grande in 1983 was delayed due to the weakening of the market following the 1981/82 recession. The 1 000 tpd mine, with an estimated investment of $25 million, plans to export tungsten to Europe and the United States.

Both major producers in Australia, Peko-Wallsend Ltd. at King Island and Queensland Wolfram at Mt. Carbine, reduced production by about one third during 1983. All but one of the other six smaller Australian operations were closed and will remain idle until the market situation improves.

Australian production of tungsten in 1983 was estimated at 2 000 t tungsten content, 17 per cent less than its 1982 production of 2 588 t. Approximately 45 per cent of Australia's total production came from King Island scheelite mine of the Peko-Wallsend Group and 42 per cent from the Mount Caroline wolframite mine of Wolfram Pty. Ltd.

Peko-Wallsend reduced production twice in 1983 at its King Island mine. However, Australia remained the western world's leading producer. Australian production of tungsten in 1984 is estimated to be approximately 3 000 t contained tungsten.

Tungsten producers in Thailand, Bolivia and South Korea all announced production cutbacks of about 30 per cent during 1982 and continued to produce at reduced capacity in 1983. It is estimated that production in these countries increased in 1984.

## MARKET STABILIZATION

International discussions on stabilizing the tungten market were held at the 15th Session of the United Nations Committee on Tungsten (COT) in Geneva on December 12-16, 1983. The Committee concluded that a Sessional Working Group should be established to assist the COT, and instructed the secretariat to prepare a discussion paper outlining the composition and organization of such a group. The Sessional Working Group is intended to provide a forum for more open discussion, including the active participation of industry advisors, and to prepare each year a reasonably detailed analysis of the market situation for the coming year.

Activity has declined in regards to a proposal for a producer-only group, especially since the Chinese voiced their belief that membership in the United Nations COT was more comprehensive and there was no need for a separate producer group. The Chinese are presently submitting statistics to the COT.

The 16th Session of the COT was held in Geneva December 10-14, 1984. The Committee agreed to establish a Sessional Working Group. A consensus was also reached by the Committee on the terms of reference for the Sessional Working Group, which includes the study of statistics and all matters relating to the tungsten market.

## PRICES

Tungsten prices, which started to decline in late-1981 continued to fall in the first half of 1983. There was a slight recovery in mid-1983, suggesting a strengthening of the market. However, a renewed weakness occurred in the last quarter of 1983 before prices resumed their upward trend, which continued throughout most of 1984. Nevertheless, prices at the end of 1984 were still well below those that existed before the 1981/82 recession.

The slow recovery of prices in the United States may have been influenced by imports from China and the auctioning of General Services Administration (GSA) stocks at a time when consumption of tungsten continued to decline.

## PRICES

| | December 31, 1982 | December 31, 1983 |
|---|---|---|
| | ($US) | |
| Tungsten ore, 65% minimum $WO_3$ | | |
| G.S.A. domestic, duty excluded, per short ton unit of $WO_3$ | 99.600 | 64.480 |
| G.S.A. export, per short ton unit of $WO_3$ | 95.090 | 74.690 |
| L.M.B. ore quoted by **London Metal Bulletin**, cif Europe, per metric tonne unit of $WO_3$ | 76.00-84.00 | 68.250-72.875 |
| Ferrotungsten, per pound W, fob Niagara Falls, low-molybdenum | list price suspended | list price suspended |
| Tungsten metal, per pound, fob shipping point Hydrogen reduced: 99.5%, depending on Fisher No. range | 13.100-13.720 | 13.100-13.720 |

Source: Metals Week.
cif Cost, insurance and freight; fob Free on board.

In May of 1984, the London Metal Bulletin (LMB) began to report the price of high-quality scheelite, in addition to the price of wolframite which has been available for several years.

Prices reported by the LMB and the International Tungsten Indicator (ITI) for the months February, July and November 1984 are summarized as follows.

| 1984 | LMB | | ITI |
|---|---|---|---|
| | Wolframite $US/tu $WO_3$ | Scheelite $US/tu $WO_3$ | $US/tu $WO_3$ |
| Feb. | 74-79 | - | 75.28 |
| July | 82-87 | 99-102 | 85.25 - 85.19 |
| Nov. | 81-84 | 85-87 | 83.43 |

- One tonne unit (tu) of $WO_3$ contains 7.93 kilograms of tungsten;
- Not published prior to May 1984

## USES

Approximately 80 per cent of the western world tungsten consumption in 1983 and 1984 was accounted for in the manufacture of cemented carbide and tool steel products, the former amounting to approximately 50 per cent of total consumption. Tungsten metal, superalloys and miscellaneous end uses accounted for the remaining 20 per cent.

Tungsten materials can be divided into several major classes, depending upon the product form and its use. The main product classes include tungsten carbide, tungsten-bearing steels, superalloys, mill products made essentially from pure metal, and chemicals.

Tungsten carbide (WC) is one of the hardest materials known and accordingly, has widespread applications where intense wear and abrasion are encountered. This product is the preferred metalworking material for the cutting edges of machine tools and as a metal surface in forming and shaping dies. It is produced by the chemical combination of tungsten metal powder and finely divided carbon. Tungsten carbide is compacted to the desired form, using cobalt as a binder, and sintered to produce cemented tungsten carbide. Cutting tools of cemented tungsten carbide are used for machining steel, cast iron and nonferrous metals, and for shaping in the woodworking and plastics industries. Cemented tungsten carbide is also used to make dies for wire and tube drawing, punches and dies for metal forming, and bits and tools for drilling equipment and wear-resistant parts. With the addition of tantalum, titanium and columbium carbides, the coefficient of friction of cemented tungsten carbides is lowered, thereby producing grades better suited to the machining of specific items, particularly steel products. Other uses of tungsten carbide are in tire studs, spikes for golf shoes, armour-piercing projectiles and welding electrodes.

As an alloy constituent, tungsten is used primarily in the production of high-speed steels, and tool and die steels. Tungsten is added to steels either as ferrotungsten (80 per cent tungsten), melting base (30-35 per cent tungsten), scheelite ($CaWO_4$) or as tungsten-bearing scrap. Tungsten-bearing steels are used for the same applications as carbides, especially where lower operating temperatures are encountered. Tungsten is also used in some stainless steels for application in high-temperature environments.

Tungsten is an important constitutent in a wide variety of superalloys and nonferrous alloys. Tungsten-containing superalloys are being used increasingly in high-temperature applications and in highly corrosive environments because of their high-temperature strength and oxidation resistance. In making the alloys, tungsten is usually added in the form of metal powder, although scrap can be used to satisfy part of the requirements. Superalloys can be classified into three principal types: nickel base, iron base and cobalt base or "Stellite" superalloys. While only small amounts of tungsten are currently used in the nickel and iron base superalloys, several companies are developing new superalloys containing larger amounts of tungsten, a factor which could significantly expand the market for tungsten.

Mill products made from pure or nearly pure tungsten metal powder are used in significant quantities by the electrical industries. The relevant important properties of tungsten for electrical applications include its high-melting point, low-vapour pressure, hardness, good electrical conductivity and low coefficient of thermal expansion. Tungsten mill products such as rods, wire and flat products are made by compressing tungsten metal powder into the desired shape and then sintering.

Discs cut from tungsten rods are used as electrical contacts to improve resistance to heat deformation resulting from sparking and associated high temperatures. Pure tungsten contacts are used principally in ignition circuits of automobiles and aircraft. However, the trend to electronic ignition systems without tungsten contacts has resulted in a decline in its use for this application. Tungsten discs are also used as heat sinks in semiconductor applications and, in combination with other elements, as electrical contacts and breakers for industrial use.

Tungsten wire is used for filaments in incandescent lamps, and heating elements in both fluorescent lamps and vacuum tubes. The overall demand for tungsten wire is increasing in response to the upward trend in the manufacture of lamps and new uses such as de-icing and defogging elements in automobile windshields.

Flat products are used for various parts of electron tubes and radiation shields as well as for very high-temperature applications in reducing or inert atmospheres.

Tungsten is used for counterweights and balances, especially by the aircraft industry, but it is being replaced by depleted uranium which has about the same density.

Minor amounts of tungsten are used to make chemicals and compounds for nonmetallurgical applications. Some of the end-uses include dyes, toners, phosphors, chemical reagents, corrosion inhibitors and catalysts.

## OUTLOOK

Currently, the world tungsten industry is characterized by a large amount of unutilized capacity (approximately 50 per cent utilization with considerable differences between countries). Although production is severely constrained, supply generally exceeds demand. Mine production capacity and utilization for the western world and selected countries for 1983, and projected capacity for 1988 are summarized in Table 4.

The demand for tungsten, like most other minerals and metals, is a derived demand. It derives from the demand for goods (end-use products) in which tungsten in one of its many forms is a component. Hence, growth in tungsten uses will be dictated by the level of economic activity in countries that are the principal users of this mineral commodity.

Although there has been an economic revival in North America, Japan and, to a lesser degree, western Europe the market price of tungsten is still at depressed levels despite improvements in the first half of 1984.

Due to the unused capacity in the world tungsten industry and given the fact that a significant portion of world supply is produced in a number of countries, the future market will remain, as it has been in the past decade, highly competitive.

The future growth rate of the Canadian industry will depend on Canada's ability to remain cost competitive in international markets. Canada's share of the world market, which stood at 20 per cent in 1982, could increase to 25 per cent by 1990 due to the high efficiency of its mining operations, large reserves of high-grade ore and aggressive marketing. These factors will contribute to Canada's ability to compete on world markets in the foreseeable future and probably beyond the year 2000.

A moderate growth rate of 2.4 per cent per annum to the year 2000 is forecast for world tungsten consumption, largely because world economic growth in general is unlikely to exceed 3.5 per cent in real terms. A relevant factor in this modest growth rate is the impact of reduced consumption due to the use in cutting tool applications of ceramics and coatings on tungsten carbide inserts. There is also substitution between tungsten products themselves, for example tungsten carbide for tungsten-alloyed high-speed tools in metal machining operations. Further in the future, there are numerous other technological developments aimed at substituting other materials for tungsten, all in an early stage of development.

It is difficult to project the long-term effect of substitution. However, it should be recognized that new applications which emerge from ongoing tungsten reasearch and development could expand the demand for tungsten more than enough to offset the substitution effect.

Developments in the recycling of scrap could have a major impact on the future consumption of tungsten ores and concentrates. Figures for scrap recycling are sparse and incomplete. However, it is estimated that of the total tungsten consumed in Canada in 1983, 20 per cent was recycled and that approximately 30 per cent of the total U.S. consumption was accounted for by recycled material. Secondary tungsten and its compounds are currently recovered from items with a high content of tungsten, such as tungsten carbide.

The degree to which partial substitution for tungsten occurs in traditional uses and the extent to which different metals are substituted for tungsten carbide, either directly or as a coating, could make the recovery of tungsten from these items both tecnnically difficult and costly. Accordingly, a smaller proportion of tungsten is likely to be sourced from scrap in the future and a correspondingly larger proportion from tungsten ores.

**TARIFFS**

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| | | | (%) | | |
| CANADA | | | | | |
| 32900-1 | Tungsten ores and concentrates | free | free | free | free |
| 34700-1 | Tungsten metal in lumps, powder, ingots, blocks or bars and scrap of tungsten alloy metal, for alloying purposes | free | free | free | free |
| 34710-1 | Tungsten rod and tungsten wire | free | free | 25 | free |
| 35120-1 | Tungsten and alloys in powder, pellets, scrap, ingots, sheets, strips, plates, bars, rods, tubing, wire, for use in Canadian manufactures (expires June 30, 1984) | free | free | 25 | free |
| 37506-1 | Ferrotungsten | free | 4.7 | 5 | free |
| 37520-1 | Tungsten oxide in powder, lumps and briquettes, for use in the manufacture of iron and steel | free | free | 5 | free |
| 82900-1 | Tungsten carbide in metal tubes for use in Canadian manufactures | free | free | free | free |

| MFN Reductions under GATT (effective January 1 of year given) | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| | | | (%) | | |
| 37506-1 | 4.7 | 4.5 | 4.3 | 4.2 | 4.0 |

UNITED STATES (MFN)

| | | | | | | |
|---|---|---|---|---|---|---|
| 601.54 | Tungsten ore, per pound tungsten content | 17¢ | | | | |
| | | 1983 | 1984 | 1985 | 1986 | 1987 |
| | | (% unless otherwise specified) | | | | |
| 422.40 | Tungsten carbide, on tungsten content | 12.5 | 12.0 | 11.5 | 11.0 | 10.5 |
| 422.42 | Other tungsten compounds | 11.0 | 10.7 | 10.5 | 10.2 | 10.0 |
| 606.48 | Ferrotungsten and ferro-silicon tungsten, on tungsten content | 8.2 | 7.5 | 6.9 | 6.2 | 5.6 |
| 629.25 | Tungsten metal waste and scrap, not over 50% tungsten | 6.3 | 5.9 | 5.6 | 5.2 | 4.9 |
| 629.26 | Tungsten metal waste and scrap, over 50% tungsten | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 |
| 629.28 | Tungsten metal, unwrought, other than alloys: lumps grains and powders, on tungsten content | 9¢/ lb + 12.5 | 3¢/ lb + 12.5 | 12.1 | 11.3 | 10.5 |
| 629.29 | Tungsten metal, unwrought, other than alloys: ingots and shot | 9.0 | 8.3 | 7.5 | 6.8 | 6.0 |
| 629.30 | Other unwrought tungsten metal | 10.5 | 9.6 | 8.6 | 7.6 | 6.6 |
| 629.32 | Unwrought tungsten alloys, not over 50% tungsten | 5.9 | 5.6 | 5.3 | 5.0 | 4.7 |
| 629.33 | Unwrought tungsten alloys, over 50% tungsten | 10.5 | 9.6 | 8.6 | 7.6 | 6.6 |
| 629.35 | Wrought tungsten metal | 9.5 | 8.8 | 8.0 | 7.3 | 6.5 |

**Sources:** The Customs Tariff, 1983, Revenue Canada and Excise Canada; Tariff Schedules of the United States Annotated 1983, USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241.

TABLE 1. CANADA, TUNGSTEN PRODUCTION, IMPORTS, 1982-84 AND CONSUMPTION 1981-83

| | 1982 | | 1983P | | 1984 | |
|---|---|---|---|---|---|---|
| | (kilograms) | ($) | (kilograms) | ($) | (kilograms) | ($) |
| **Production**[1] ($WO_3$) | 3 029 730 | .. | 1 537 880 | .. | | |
| **Imports** | | | | | (Jan.-Sept. 1984) | |
| Tungsten in ores and concentrates | | | | | | |
| United States | 7 620 | 104,000 | 9 000 | 121,000 | 7 000 | 108,000 |
| Peoples Republic of China | - | - | 3 000 | 15,000 | - | - |
| Total | 7 620 | 104,000 | 12 000 | 136,000 | 7 000 | 108,000 |
| Ferrotungsten[2] | | | | | | |
| United States | 4 536 | 160,000 | 3 000 | 78,000 | 5 000 | 124,000 |
| West Germany | -- | 5,000 | - | - | - | - |
| Total | 4 536 | 165,000 | 3 000 | 78,000 | 5 000 | 124,000 |
| Tungsten carbide powder | | | | | | |
| United States | 249 000 | 4,973,000 | 197 000 | 5,170,000 | 218 222 | 5,472,000 |
| Other countries | 25 000 | 857,000 | 23 000 | 618,000 | 22 544 | 550,000 |
| Total | 274 000 | 5,830,000 | 220 000 | 5,788,000 | 240 766 | 6,022,000 |
| | (number) | ($) | (number) | ($) | (number) | ($) |
| Tungsten carbide rotary rock drill bits | | | | | | |
| United States | 6 829 | 32,327,000 | 9 187 | 46,127,000 | 6 291 | 26,295,000 |
| Other countries | 3 395 | 3,616,000 | 560 | 1,825,000 | 794 | 3,636,000 |
| Total | 10 224 | 35,943,000 | 9 747 | 47,925,000 | 7 085 | 29,931,000 |
| Tungsten carbide percussion rock drill bits | | | | | | |
| Ireland | 68 744 | 1,277,000 | 139 654 | 2,587,000 | 87 579 | 1,486,000 |
| United States | 19 043 | 1,452,000 | 42 114 | 1,467,000 | 38 942 | 1,405,000 |
| Other countries | 1 738 | 109,000 | 3 589 | 107,000 | 7 762 | 183,000 |
| Total | 89 525 | 2,838,000 | 185 357 | 4,161,000 | 134 283 | 3,056,000 |
| Tungsten carbide tools for metal work | | | | | | |
| United States | .. | 5,835,000 | .. | 6,152,000 | .. | 8,211,000 |
| Other countries | .. | 1,595,000 | .. | 2,722,000 | .. | 2,785,000 |
| Total | .. | 7,430,000 | .. | 8,874,000 | .. | 10,996,000 |
| | 1981 | | 1982 | | 1983 | |
| | (kilograms) | ($) | (kilograms) | ($) | (kilograms) | ($) |
| **Consumption** (W content) | | | | | | |
| Tungsten metal and metal powder | 377 815[r] | .. | 466 672 | .. | 487 463 | .. |
| Other tungsten products[3] | 23 632[r] | .. | 18 934[r] | .. | 16 188 | .. |
| Total | 401 447[r] | .. | 485 606 | .. | 503 651 | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments. [2] Gross weight. [3] Includes tungsten ore, tungsten carbide and tungsten wire.
P Preliminary; [r] Revised; - Nil; .. Not available; -- Small amount not quantified.

### TABLE 2. CANADA, TUNGSTEN PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975, 1979-83

| | Production[1] | Imports<br>Tungsten Ore[2] | <br>Ferrotungsten[3] | Consumption[2] |
|---|---|---|---|---|
| | (kilograms) | | | |
| 1970 | 1 690 448 | 82 645 | 90 718 | 446 687 |
| 1975 | 1 477 731 | 1 000 | 45 359 | 451 336 |
| 1979 | 3 254 000 | 11 000 | 28 000 | 380 229 |
| 1980 | 4 007 000 | 6 000 | 7 000 | 290 479 |
| 1981 | 2 515 000 | 14 000 | 6 000 | 401 447[r] |
| 1982 | 3 029 730 | 7 620 | 4 536 | 507 606 |
| 1983P | 1 537 880 | 12 000 | 3 000 | .. |

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments of scheelite ($WO_3$ content); [2] W content; [3] Gross weight.
P Preliminary; [r] Revised; .. Not available.

### TABLE 3. WORLD TUNGSTEN PRODUCTION IN ORES AND CONCENTRATES, 1981-83

| | 1981 | 1982P | 1983[e] |
|---|---|---|---|
| | (tonnes of contained tungsten: W content) | | |
| People's Republic of China | 13 517 | 12 519 | 10 000 |
| U.S.S.R. | 8 845 | 8 981 | 9 000 |
| Bolivia | 2 779 | 2 534 | 3 000 |
| Australia | 3 517 | 2 588 | 2 000 |
| Republic of Korea | 2 642 | 2 233 | 2 000 |
| Canada | 1 995 | 2 403 | 1 220 |
| Austria | 1 450 | 1 406 | 1 200 |
| Portugal | 1 395 | 1 361 | 1 200 |
| United States | 3 605 | 1 521 | 1 100 |
| Brazil | 1 249 | 1 089 | 1 000 |
| Thailand | 1 210 | 856 | 700 |
| Burma | 825 | 844 | 500 |
| Turkey | 153 | 150 | 200 |
| Mexico | 263 | 99 | 100 |
| Other central economy countries | 2 279 | 2 279 | 2 300 |
| Other market economy countries | 3 484 | 3 465 | 2 800 |
| World total | 49 208 | 44 328 | 38 320 |

Sources: United States Bureau of Mines Minerals Yearbook Preprint 1982; USBM Mineral Commodity Summaries, 1984; Energy Mines and Resources Canada.
P Preliminary; [e] Estimated.

### TABLE 4. WESTERN WORLD AND SELECTED COUNTRIES, 1983 MINE CAPACITY AND PER CENT UTILIZATION, AND 1988 FORECASTED CAPACITY

| | 1983<br>Capacity[e] | <br>% Utilization[1] | 1988<br>Capacity[e] |
|---|---|---|---|
| | (tonnes W content) | | |
| Canada | 5 200 | 4 | 6 440 |
| United States | 4 575 | 24 | 4 575 |
| Bolivia | 3 500 | 86 | 3 550 |
| Brazil | 1 280 | 78 | 1 280 |
| Austria | 1 600 | 75 | 1 600 |
| France | 840 | 89 | 840 |
| Portugal | 1 570 | 76 | 1 570 |
| Spain | 460 | .. | 460 |
| Sweden | 400 | .. | 400 |
| United Kingdom | 75 | 67 | 75 |
| South Africa | 420 | .. | 1 130 |
| Japan | 700 | .. | 2 800 |
| South Korea | 2 800 | 71 | 2 800 |
| Thailand | 1 750 | 40 | 1 750 |
| Turkey | 1 000 | 20 | 1 000 |
| Australia | 3 400 | 59 | 3 400 |

Sources: Chase Econometrics World Ferroalloy Report, January 1984 Update, Tungsten; USBM Mineral Commodity Summaries, 1984; Energy, Mines and Resources Canada.

[1] Per cent utilization calculated.
[e] Estimated; .. Not available.

# Uranium

R.T. WHILLANS

The outlook for the uranium market is expected to remain unsettled throughout the 1980s with little sign of improvement in the short term. Further cancellations and delays in planned nuclear power programs and the continued accumulation of uranium inventories, will prolong the uncertainty within the uranium industry worldwide.

Despite a decline in annual uranium production from the peak levels of 1980-81, output is expected to exceed requirements to the end of the decade and swell stockpiles now estimated to be equivalent to 4 or 5 years forward supply.

Uranium requirements are forecast to grow at a rate of 6 per cent per annum to 1990 as the planned doubling in installed nuclear capacity is realized. However, market opportunities in the next few years will be limited, as much of this growth can be supplied from inventory. In Canada, this growth continues to sustain uranium exploration efforts which, though diminished in comparison with the 1979-80 peak, remain significant.

In Ontario, Rio Algom Limited and Denison Mines Limited will continue their efforts beyond 1985 to reduce costs and improve overall productivity; underground leaching is expected to contribute significantly toward achieving these objectives. In Saskatchewan, Eldorado Resources Limited is developing its Collins Bay "B" orebody for production in 1986, Cluff Mining is proceeding with Phase II of the Cluff Lake operation, Key Lake Mining Corporation (KLMC) could commence development of the Deilmann orebody before the end of the decade, and COGEMA Canada Limited is continuing the evaluation of the very promising Cigar Lake deposit, the discovery of which was announced in early 1983.

## PRODUCTION AND DEVELOPMENT

During 1984, Canada's five primary uranium producers, Denison Mines Limited, Rio Algom Limited, Eldorado Resources Limited, Cluff Mining and Key Lake Mining Corporation produced concentrates containing an estimated 11 170 tU.* With the phasing in of committed development plans in Saskatchewan and recently completed projects in Ontario, annual production capability is expected to stabilize at about 12 000 tU through the mid to late 1980s. As domestic requirements are small, some 15 per cent of current output, most of Canada's production will be exported. (See Table 1 for a comparison of primary uranium production for the years 1982 and 1983, and Table 2 for a summary of the 1983 operating characteristics of Canada's uranium production centres).

Of Canada's total uranium shipments in 1984, some 55 per cent was attributable to the three Saskatchewan operations with the balance coming from the two Ontario producers at Elliot Lake (see Table 3).

A milling rate of some 10 000 tpd of ore has been deemed adequate at the Elliot Lake, Ontario, operations of Denison Mines Limited to meet production and delivery schedules required under long-term sales contracts. These approach 60 000 tU and extend to 2012. Such commitments suggest that for the next several years, Denison will likely maintain its current production rate of approximately 2 300 tU per year.

The underground, in-place leaching tests being conducted by the company continue to show favourable results. Together with better training, improved machinery and high-grade-pillar recoveries, the leaching program will become an increasingly important part of Denison's efforts to reduce costs and enhance productivity. It is expected to ave contributed up to 10 per cent of the company's 1984 production and may account for up to 20 per cent of future production as more working areas become available. All major works for the expansion of the Denison main property were completed by year-end 1983. At that time the adjoining Stanrock/Can-Met mine was placed on a care-and-maintenance basis, since production from this area will not be required to meet commitments to Ontario Hydro until a future date.

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* tU = One metric ton (tonne) of elemental uranium (U), written as tU, is equivalent in terms of uranium content to 1.2999 short tons of uranium oxide ($U_3O_8$).

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At the Elliot Lake operations of Rio Algom Limited, overall production during 1984 was expected to reach 2 700 tU. As part of a plan implemented in late 1982 to match production more closely with deliveries made under existing contracts, combined ore output from the three production centres (Quirke, Panel and Stanleigh) has been established at about 12 000 tpd. This rate is adequate to meet deliveries under long-term sales contracts which total some 44 000 tU through to the year 2020.

Rio Algom's intensive and ongoing efforts to reduce costs and increase productivity have proven effective. Costs are being trimmed through mechanization, improved training and by driving development headings in ore. The company's underground in-place leaching program is also of major importance. Production from leaching could reach 20 per cent of total output in the near future.

Completed below budget, the rehabilitation of the Stanleigh property marked the end of Rio Algom's multi-million dollar expansion program started in 1975. The Stanleigh mill commenced production on schedule in July 1983 and achieved targetted throughput by year-end 1984. During the 40-year life of the operation, some 28 000 tU will be delivered to Ontario Hydro which has financed the project and will purchase its entire output.

At Bancroft, Ontario, Madawaska Mines Limited submitted its decommissioning and close-out proposal to the Atomic Energy Control Board (AECB) in June 1983. The following November, the AECB announced that decommissioning approvals for the Madawaska mining facility had been authorised, subject to certain conditions. During 1984, work agreed upon under the approved decommissioning licence was substantially completed. After a period of monitoring the property can revert to the Crown.

The salvage leaching operation of Agnew Lake Mines Limited, 90 km east of Elliot commencement of operations in 1977 was 752 tU. The company reported that its uranium loan from Eldorado was repaid and that the AECB had approved the company's plan to decommission and close out the property. Most of the surface rehabilitation and tailings area stabilization was completed by early 1984. If compliance with environmental standards is satisfactory after the prescribed monitoring period, the property can be returned to the Crown.

Production in 1984 from the Rabbit Lake, Saskatchewan, operation of Eldorado Resources Limited was expected to match previous year output levels. The Rabbit Lake orebody was mined out in August 1984 and the company is completing the preparation of the depleted pit as a disposal facility for the tailings from the Collins Bay "B" deposit.

After signing a surface lease agreement with the Government of Saskatchewan in March 1983 (see Government Affairs), Eldorado commenced work on the development of its Collins Bay "B" orebody, some 9 km northeast of the Rabbit Lake mill, spending in excess of $26 million during 1983. Retaining dykes are in place at the site, damming off the small bay which overlies the deposit. The bay has been drained and stripping of the overburden is well underway. The project includes modifications to the 1 500 tpd capacity Rabbit Lake mill to facilitate the processing of a wider range of complex uranium-bearing ores. Hydrogen peroxide will be used instead of ammonia in the precipitation of mine concentrates in order to meet stringent environmental criteria.

The completion of the Collins Bay "B" expansion will return Eldorado's annual production capability to 2 000 tU. Ore stockpiled from the Rabbit Lake open pit will provide feed until 1986, when first production from the "B" deposit is expected. The reported cost of the project is $100 million of which approximately $60 million had been committed by the end of 1984.

In northwestern Saskatchewan, Cluff Mining - owned 80 per cent by Amok Ltd. and 20 per cent by Saskatchewan Mining Development Corporation (SMDC) - completed construction of its Phase II facilities in August 1984, two months ahead of schedule. Cluff Mining's Environmental Impact Assessment and surface lease arrangement were accepted in early 1983, by the Government of Saskatchewan (see Government Affairs). The company was issued an Underground Exploration Permit in July and application for a Mining Facility

Operating Licence (MFOL) was before the AECB at year-end 1983. A two-year MFOL for Phase II was granted effective August 1, 1984.

Stripping of the Claude deposit commenced in early 1983 and dewatering of the "O-P" workings started in the second quarter. Work on the decline from surface of the new "O-P" mine was completed in November 1983 in preparation for the underground development of the deposit, and to permit the eventual advancement to the much larger "Dominique-Peter" orebody nearby. Phase II production began in April 1984 from the exploitation of the "O-P" underground and "Claude" open-pit mines and will shift to the "Dominique-Peter" underground mine around 1985, as the "O-P" deposit is depleted. The "N40" underground and "N" open-pit mines could be brought into production in the 1990s. Phase II facilities, designed to process ore of a more conventional grade than the very high-grade "D" orebody exploited during Phase I of the operation, will have the capability of mining and milling some 230 000 tpy of ore to produce between 850 and 1 270 tU annually.

During January and February of 1983, some 700 t of preconcentrated ore from the Phase I gravimetric separation circuit was processed; this material graded over 310 kgU/t. From March 1983 to year-end, a small solvent extraction circuit, designed to reprocess Phase I residues, treated some 30 000 t of gravimetric separation rejects, grading over 15 kgU/t.

Key Lake Mining Corporation (KLMC) commenced ore processing at its Key Lake operation in northern Saskatchewan in early October 1983. By month-end, the first uranium concentrates had been packaged and the facility was operating at 40 per cent capacity. Commissioning continued through November toward commercial production and mill recovery rates of 95 per cent were attained by December 1983. Operated by KLMC - jointly owned by Saskatchewan Mining Development Corporation (one-half), Uranerz Exploration and Mining Limited (one-third), and Eldor Resources Limited, wholly-owned by Eldorado Nuclear Limited, (one-sixth) - the $500 million project came on-stream close to schedule and 11 per cent under budget.

The ceremonial opening of the Key Lake operation took place on June 1-2, 1984. In July, production surpassed the nominal monthly output capacity of 385 tU, prompting estimates that output in 1984 could total 4 200 tU. Upon achieving its annual design output level of some 4 600 tU, the Key Lake operation will become the world's largest uranium production centre.

To overcome problems caused by the high clay content of the ore, installation of a semi-autogenous grinding (SAG) mill was undertaken in May 1984. Completed late in the year at a cost of some $7 million, the independent SAG circuit should ensure continuity of production at design throughput levels.

Production resumed in mid-1983 at the byproduct uranium recovery plant operated by Earth Sciences Extraction Company at Calgary, Alberta. The facility, placed on standby in late October 1981, underwent major equipment modifications to improve recoveries of uranium from phosphoric acid produced at an adjacent plant operated by Western Co-operative Fertilizers Limited. Testing of the modified circuits commenced in June 1983 and by September the plant was operating at 90 per cent of its 40-60 tU/yr* design capacity. The facility is owned by a partnership of ESI Resources Limited, a wholly-owned subsidiary of Earth Sciences Inc. of Golden, Colorado, and Urangesellschaft Canada Limited, a subsidiary of Urangesellschaft mbH of Frankfurt, Federal Republic of Germany.

As shown in Table 4, the work force at Canada's producing uranium operations as of January 1984 totalled some 5,850 employees. Of this total, over 2,500 worked in the mines, both open-pit and underground, and some 780 in the mills, with the balance described as general employees. Head-office and construction-related employment is not included. The 5,850 figure, showing close similarity with the 1981 total of some 6,000 employees, reveals that many of the 1,200 jobs lost during 1982/83, primarily as a result of the cessation of production at Madawaska, the closure of Beaverlodge in northern Saskatchewan, and the phasing out of operations at Agnew Lake, have been regained as a result of the start-up of new and expanded uranium production facilities.

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* Output from ESI is not included in Canadian production totals because the uranium is recovered from phosphate rock imported from the United States. This uranium is contracted to American utilities.

## EXPLORATION

The Uranium Resource Appraisal Group (URAG) of Energy, Mines and Resources, Canada, (EMR) completed its tenth (1983) resource assessment and exploration survey during 1984. EMR reported* that overall uranium exploration activity in Canada declined in 1983 for the third consecutive year, in terms of both drilling effort and level of total expenditures. Responses to the 1983 URAG questionnaire indicated the exploration activities of 71 companies or joint ventures representing essentially all the major participants active in uranium exploration in Canada. The survey showed that 52 companies or joint ventures were actively involved in uranium exploration in 1983, of which 29 acted as project operators. Total expenditures reached $41 million, distributed amongst some 90 active projects.

The 10 operators** with the largest exploration budgets in 1983 - accounting in aggregate for some 94 per cent of the $41 million total, were, in alphabetical order, AGIP Canada Ltd., Amok Ltd., Anaconda Canada Exploration Ltd., Eldor Resources Limited, PNC Exploration (Canada) Co. Ltd., Saarberg Interplan Canada Ltd., Saskatchewan Mining Development Corporation (SMDC), SERU Nuclear (Canada) Limited (now COGEMA Canada Limited), Uranerz Exploration and Mining Limited, and Urangesellschaft Canada Limited. Six of those companies were amongst the top 10 from 1979 to 1983, inclusive.

Eight of the above 10 operators are companies whose majority interests are held outside of Canada; seven of those eight are supported, directly or indirectly, by their national governments in their uranium exploration efforts. Thus, in spite of the falling uranium market price, Canada continues to attract foreign investment for uranium exploration.

Not all companies that responded to the 1983 URAG questionnaire had planned their exploration expenditures for 1984 at the time of the survey. However, from the preliminary estimate of $35 million, it appears that the decline in exploration expenditures in 1984 has been less severe than in the past few years.

Indeed, the preliminary estimates for 1984 reveal that drilling activity will be in the order of 165 000 metres, representing an increase of some 8 per cent over the effort in 1983.

As in the previous three years, virtually all the surface development drilling in 1983 was associated with major programs in the Athabasca Basin of Saskatchewan. Most other exploration drilling was done in Quebec and the Northwest Territories.

Despite the downturn in the level of uranium exploration that began in 1980, and the prohibition of such activity in favourable areas because of provincial moratoria (British Columbia and Nova Scotia) or their consideration as park/wildlife areas (Yukon and Northwest Territories), annual exploration expenditures in the order of $40 million continue to represent a significant level of activity compared with other uranium producing areas of the world.

Figure 1 illustrates the responsiveness of uranium exploration expenditures in Canada to uranium price movements since the early 1970s. The decline in uranium exploration expenditures, in an apparent response to softening in the uranium market, has become increasingly evident with each successive survey since 1980.

Of particular significance, as a boost to the uranium exploration industry, was the announcement in March 1983 by SERU Nuclear (Canada) Limited, operator of the Waterbury Lake joint venture in the eastern Athabasca Basin of Saskatchewan, that significant uranium mineralization had been discovered at Cigar Lake. In May 1984, project majority-owner SMDC announced that continued drilling at Cigar Lake had demonstrated the existence of resources estimated to contain 88 500 tU grading an average 8.5 per cent U. Some 70 per cent of these resources were identified as drill-indicated, the balance as inferred. Drilling has extended the strike length of the deposit to 1 850 m, over widths from 25 to 115 m, and thicknesses from 1 to 19 m. The orebody is located at a depth of 410 to 440 m. High grade material averaging up to 32 per cent U across 19 m has been intersected.

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* Energy, Mines and Resources Reports Uranium Supply Assessment Results, Communiqué 84/98, October 11, 1984.

** An operator may incur expenditures on a project either alone or in a joint venture. In the latter case, the combined expenditure of all participants is attributed to the project operator; as such, contributions by other parties not responding directly to the URAG survey are accounted for in the total.

The preliminary engineering and mining studies that were initiated in 1983 and continued in 1984 will confirm the dimensions and grades in the richest part of the deposit. Pre-development studies are underway, including an environmental baseline program. The joint venture partners are SMDC (50.75 per cent), COGEMA (37.375 per cent), and Idemitsu Uranium Exploration Canada Ltd. (11.875 per cent). COGEMA acquired the minority interest share in Cigar Lake held by Reserve Oil and Minerals Corporation (3.75 per cent) in July 1984.

To the northeast of Waterbury Lake, equal partners Canadian Occidental Petroleum Ltd. and Inco Limited followed up the conceptual study, which Inco completed in December 1982, for the underground mining of their McClean deposits. These occur at depths varying from 152 to 175 m and reportedly contain in excess of 5 000 tU. It was planned to test the proposed mining method over a two-year pilot program commencing in 1984. Although approval of an Underground Exploration Permit from the AECB was granted by the end of 1983, the program did not get underway during 1984.

## URANIUM RESOURCES

The results of EMR's interim-year URAG uranium resource assessment, released in October 1984, are summarized in Table 6. For comparison, the results of the 1982 assessment* are also presented. Uranium resource estimates are divided by URAG into separate resource categories which reflect different levels of confidence in the quantities reported. For the 1983 assessment, these categories were subdivided into three levels of economic exploitability related to the market price of uranium. The low price range (A) was limited at the upper bound by the uranium market price estimated in Canadian dollars at $100/kg U in December 1983, when most of the data for the assessment were gathered (see Markets and Prices for derivation). Tonnages assigned to the A price category, therefore, provide a measure of those Canadian uranium resources that were of economic significance, as of the date of the assessment. The second price range (B) and third price range (C) spanned the $100-$150/kg U, and the $150-$300/kg U intervals, respectively. All quantities are reported in tonnes of elemental uranium, consistent with international practice. Prices are given in Canadian dollars/kg U*.

In comparing the 1983 estimates of Canada's mineable uranium resources with those of the 1982 resource assessment, the most significant change to note is the 22 per cent increase in Indicated resources in contrast to the 10 and 7 per cent decreases in the Measured and Inferred resource categories, respectively; the increase primarily reflects the results of continued exploration and development work in northern Saskatchewan. The sum of Measured, Indicated, and Inferred resources, within all three price categories, was 591 000 tU. This is slightly higher than the comparable 1980 figure despite production of some 23 000 tU in the intervening three-year period!

To provide an illustration of uranium availability in the short term, a projection of Canadian production capability to 1996 was made, as illustrated in Figure 2. This scenario is an illustration of firm production capability. It is based on existing and committed production centres only, and assumes levels of production that can be practically and realistically achieved, under favourable circumstances. Only resources in the Measured, Indicated and Inferred categories, in the A plus B price range (i.e., mineable at uranium prices of $150/kg U or less), were incorporated into the projection. The lives of these production centres could be extended, in certain cases, by the exploitation of associated higher-priced resources, or through additions of resources in the A plus B price range resulting from continued exploration and development work.

This production capability scenario is not intended to represent a projection of actual production. Rather, it is intended to illustrate a level of production that could be supported by known deposits, given favourable developments in the uranium market. Actual levels of production from these centres will depend on a number of operational variables, and could be different from the capabilities projected.

## GOVERNMENT AFFAIRS

On March 28, 1983, Northern Saskatchewan Minister George McLeod announced the signing of a surface lease agreement by the provincial government and Eldorado Resources Limited. It gave Eldorado the go-ahead to develop the Collins Bay "B" orebody and thereby expand mining operations at its Rabbit Lake uranium mine/mill complex near Wollaston Lake, northern Saskatchewan. Granting of the surface lease also signified the agreement between the government and Eldorado concerning environmental protection, health and safety of workers, and development of economic and employment opportunities.

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* *Uranium in Canada*: 1982 Assessment of Supply and Requirements, Report EP 83-3, Energy, Mines and Resources Canada, September 1983.

* $1/lb $U_3O_8$ = $2.6/kg U

Cluff Mining received environmental approval on June 7, 1983 from the Saskatchewan Minister of the Environment to proceed with Phase II of its Cluff Lake operation; on December 5 the surface lease agreement was finalized with the provincial government. Phase II will involve the exploitation of two open-pit and three underground mines adjacent to the present facility, and permit production to continue into the 1990s.

In September 1983, the Government of Canada made known the results of its recent review of Canadian uranium export policy*. While deciding to retain the basic principles of the existing policy, the intent of which was to ensure that Canada remains a reliable supplier of uranium to world markets, Ministers agreed to make several modifications to its implementation. The review covered three elements of the policy: security of domestic supply, further processing and commercial terms and conditions.

As the security of domestic supply seems to be less urgent than in 1974, when the last review of uranium export policy took place, Ministers decided that the supply situation should be monitored on a national rather than on an individual producer basis. As long as there is no urgent security of supply problem, individual producers would be free to sell uranium for export. Contracts can now be approved for up to 15 years, and in the case of uranium exports associated with new CANDU sales, approval can be granted for contracts which provide a uranium supply for up to 30 years for each CANDU exported.

In the case of further processing, Ministers reaffirmed the policy that uranium should be upgraded to the greatest extent possible in Canada before export. In practice, this means conversion to $UF_6$. The policy provides for the regulating agencies to consider requests for exemptions from the further processing provision if the Canadian facilities do not have the capacity or if they are not generally competitive in the world scene. Exemptions for other reasons would only be granted in the most exceptional circumstances. The further processing objective is a long-standing one and is not limited to uranium.

With respect to commercial terms and conditions, Ministers decided to reaffirm the requirement for a floor price or similar mechanism that would protect investment and employment in uranium production facilities. At the same time, the terms of sale should equitably balance benefits and risks and should generally be in accord with those being obtained by Canadian and international producers for uranium under contracts of similar duration.

It was also agreed that uranium export contracts will continue to be reviewed by the Uranium Exports Review Panel to ensure that they are consistent with Canada's policy. Acceptance by Ministers of the contract terms and conditions will remain a necessary step prior to the consideration by the regulating agencies of applications for export permits. The Panel will make every effort to ensure that the contract review is as expeditious as possible.

In the United States, an amendment to the Nuclear Regulatory Commission (NRC) Authorization Act for fiscal years 1982 and 1983 was passed in January 1983 that requires the Department of Energy (DOE) to monitor the uranium industry and make, for the years 1983 to 1992, an annual determination of its viability. A structure for the government's monitoring of that viability was established. The criteria to be used for the determination were published in the **Federal Register** in October 1983. A mechanism provides for the initiation of investigations by the U.S. International Trade Commission and the Secretary of Commerce, respectively, if it is determined that the level of uranium imports will be a substantive cause of serious injury to the U.S. uranium industry, or if imports exceed 37.5 per cent of domestic uranium requirements for two consecutive years, or if the level of imports threatens or impairs national security. The actual determination of viability rests with the Secretary of Energy.

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* See **"Canada's Role as a Uranium Supplier"**, an address by Dr. R.W. Morrison, Director-General, Uranium & Nuclear Energy Branch, EMR, to the Fourth Pacific Basin Conference, Vancouver, September 13, 1983.

Pursuant to the requirements set forth in the NRC Authorization Act, a comprehensive one-time review on the status of the U.S. uranium mining and milling industry was prepared and submitted to Congress on behalf of the President in May 1984. In addition to presenting projections of industry behaviour under current policy, the report presents projections under alternative policy scenarios, in the event that foreign uranium import restrictions were enacted by Congress.

The release date of the Secretary of Energy's first annual determination of industry viability, based on the criteria of resource capability, supply response capability, financial capability, and import commitment dependency, may be delayed in light of a December 1984 lawsuit, filed against DOE by certain U.S. uranium producers, that challenges the criteria of industry viability.

In December 1983, federal Justice Minister Mark MacGuigan indicated that the federal government was dropping charges against Denison Mines Limited, Rio Algom Limited, Gulf Minerals Canada Limited and Uranerz Canada Limited, following an earlier decision by the Supreme Court of Canada that the alleged co-conspirators, Eldorado Nuclear Limited and Uranium Canada, Limited, as agents of the Crown, were not subject to prosecution under Section 32 of the Combines Investigation Act.

The six companies, charged in July 1981 under the Combines Investigation Act, were alleged to have unlawfully conspired, combined, agreed or arranged to prevent or lessen, unduly, competition in the production, manufacture, sale or supply in Canada of uranium oxide and other uranium substances between September 1, 1970 and April 1, 1978.

## MARKETS AND PRICES

Canadian producers continue to play an active role in the uranium market. During 1983 and 1984, a significant number of new export contracts were reviewed and accepted by the federal government. As shown in Table 7, net additions resulting from new and revised contracts in 1983 and 1984, brought to some 104 000 tU, the total amount of uranium under export contracts reviewed since September 5, 1974. The year-end 1984 total reflects scheduled deliveries under more than 110 contracts, over one third of which remain active. As of December 1984, forward commitments under all active contracts were estimated at 63 000 tU. Forward domestic commitments exceed 75 000 tU.

Actual exports in 1983 exceeded 3 800 tU, and were primarily to the United States, Japan and the United Kingdom (see Table 8). Japan has been Canada's most important single customer, receiving about 31 per cent of Canada's total exports over the last decade. Most of the remaining exports have gone to the European Economic Community (33 per cent), other countries in western Europe (18 per cent), and the United States (17 per cent).

In January 1983, SMDC and the New Brunswick Electric Power Commission (NBEPC) announced the signing of a long-term contract whereby SMDC will supply uranium concentrates required for NBEPC's Point Lepreau CANDU reactor. Some 80 tU will be required annually during normal operation of the station.

In Canada the average price for 1983 under all export contracts made by Canadian producers for deliveries in 1983 was $Cdn 98.30/kg U ($US 30.40/lb $U_3O_8$). In the United States data gathered from essentially all of the principal companies involved in domestic uranium marketing activities indicate that the reported price of U.S. uranium for 1983 delivery averaged $US 37.81/lb $U_3O_8$ ($Cdn 122/kg U). Similar to the above-mentioned Canadian and U.S. average prices, the weighted average price for 1983 deliveries to consumers in the European Economic Community, under medium- to long-term contracts, was reported at $US 31/lb $U_3O8$ ($Cdn 100/kg U).

By comparison, uranium spot market prices were significantly lower, as reflected by the Nuclear Exchange Corporation* (Nuexco) monthly exchange value** (EV). The EV rose from $US 17/lb $U_3O_8$ in September 1982 to a high of $US 24 in July, before slipping to $US 22/lb $U_3O_8$ by year-end 1983. It hit a 10-year low of $US 15.25 lb $U_3O_8$ by the end of 1984.

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* A California-based uranium brokerage firm.
** Nuexco's judgement of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the last day of the month.

## REFINING

Eldorado Resources Limited, operates Canada's only uranium refining/conversion facilities. To keep pace with increasing domestic uranium concentrate production capability, expansions of the company's refining and conversion capacity have been under way during the past few years. These commitments were made in anticipation of greatly increased world requirements for uranium and for associated further processing services. Canada is now in a position to refine and convert the full output of its expanded uranium production industry.

At a new Blind River, Ontario, plant, uranium concentrates from mines in Canada and other countries are refined to high purity uranium trioxide ($UO_3$)*. The $UO_3$ is then converted at Port Hope, Ontario, into either uranium hexafluoride ($UF_6$)** for foreign utilities that operate light water reactors, or ceramic-grade uranium dioxide ($UO_2$) for CANDU-type heavy water reactors.

Construction of the 18 000 tU/year Blind River facility was completed, within budget, in July 1983 at a total cost of approximately $145 million. Production commenced in October after a short commissioning phase to test the design capacity and the product quality, and reached commercial levels in early 1984. Start-up of this new facility permitted the closure of Eldorado's old refinery at Port Hope.

The refined $UO_3$ is transported from Blind River to Eldorado's conversion plants in Port Hope. There the new $120 million $UF_6$ facility, with an annual output capacity of 9 000 tU as $UF_6$, was essentially completed, within budget, by the end of 1983. Commissioning of the facility began in early 1984, first production was achieved in June, and commercial production levels were anticipated in January 1985.

The new refinery at Blind River also gives Eldorado the capability to utilize fully its enlarged $UO_2$ conversion facility at Port Hope, the capacity of which was doubled to 2 800 tU as $UO_2$ during the upgrading/expansion program of 1980.

In total, Eldorado processed mine concentrates containing some 5 564 tU during 1983, a 12 per cent decrease from 1982; the decline was largely the result of lower demand in the world market for $UF_6$.

## NUCLEAR POWER DEVELOPMENTS

Despite the very slow rate of new reactor orders in the world, the number of operating reactors will continue to grow steadily into the 1990s. The International Atomic Energy Agency (IAEA) reported that at the end of 1983, 317 nuclear power reactors, with a combined generating capacity of some 191 electrical gigawatts (GWe)*, were on-line in national grids in 25 countries. Although nuclear programs in some countries are still small, in others the nuclear share in electricity production at times of low demand often exceeds 50 per cent (Table 11).

At year-end 1983, a further 209 reactors with a combined capacity of 194 GWe were under construction. The IAEA estimates that the total world installed nuclear capacity will amount to 275 GWe by 1985, and will grow to between 370 and 400 GWe by 1990 and to between 580 and 850 GWe by the turn of the century.

In Canada, 14 CANDU reactors with an aggregate net output capacity of 8,097 electrical megawatts (MWe) were in service (i.e. commercially operable) at year-end 1984 and a further 9 reactors with an additional capacity of some 6,806 MWe were either in the pre start-up phase or under construction (see Table 12). Nuclear generation in Canada exceeded 46 TWh** in 1983, an increase of some 28 per cent from 1982; it accounted for 12 per cent of total Canadian electricity generation. Canada's commitment to nuclear power remains firm.

Ontario Hydro's nuclear reactors maintained their standing among the world's best performers. To the end of 1983, 7 of Hydro's 9 in-service CANDU's were in the top 10 in terms of lifetime capacity factor† out of some 168 commercial power reactors, rated at 500 MWe or greater, in service around the world.

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* Uranium trioxide is the initial refined product from which $UO_2$ or $UF_6$ is produced.
** Uranium hexafluoride is the required feed material for the uranium enrichment process.

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* GWe = $10^9$ watts.
** Terawatts-hours = $10^{12}$ watt-hours.
† Lifetime capacity factor is the ratio of electricity produced, from the in-service date of the reactor, relative to that which could have been produced had the reactor operated at 100 per cent power output for 100 per cent of the time.

Some 35 per cent of the total electrical energy generated by Ontario Hydro during 1983 came from nuclear-electric units; 33 per cent was derived from hydro-electric sources and 32 per cent came from coal-fired plants.

At Ontario Hydro's four-reactor Pickering "B" Nuclear Generating Station (NGS) east of Toronto, unit 5 was declared in service on May 10, 1983. The commissioning of unit 6 proceeded favourably through 1983; the reactor reached 95 per cent of full power by year-end and was declared in service on February 1, 1984. The most probable in-service dates for units 7 and 8 are December 1984 and July 1985, respectively.

On August 1, 1983, a pressure tube rupture in unit 2 of the adjacent Pickering "A" NGS resulted in the manual shut down of the reactor; unit 1 was shut down on November 14 so that the extent and severity of the problem could be assessed. The cause of the rupture has been identified and is limited to these two early units. The fuel channel replacement program, started in 1984, will see Pickering Units 1 and 2 back on line by November 1, 1986 and February 1, 1987, respectively.

Ontario Hydro received approval in principle in November 1983 from the AECB for an operating licence for full electric power at unit 6 of the Bruce "B" NGS near Kincardine. The reactor, the first completed of the four-unit station, is capable of generating 750 MWe. It produced first electricity in June 1984 and was declared in service on September 14, 1984. Unit 5, the next reactor to be commissioned, achieved criticality on November 15, 1984 and is scheduled to go into service by April 1985. The expected in-service dates for Units 7 and 8 are April 1, 1986 and January 1, 1987, respectively.

On May 5, 1984, the Douglas Point CANDU prototype, located in the Bruce Nuclear Power Development, was taken out of service. In addition to electricity generation, the Douglas Point facility, owned and operated by Atomic Energy of Canada Limited (AECL), supplied process heat to Ontario Hydro's heavy water production plants and served as a training and R&D centre.

At Ontario Hydro's Darlington NGS near Bowmanville, construction remained on schedule; the most probable in-service dates for units 1 to 4 are February 1989, May 1988, November 1991 and August 1992, respectively.

In New Brunswick, Canada's first 600 MWe series CANDU reactor to go into commercial operation, Point Lepreau I, was declared in service on February 1, 1983. The AECB authorized the New Brunswick Electric Power Commission on March 22, 1983 to operate the reactor at 100 per cent of full power; the facility reached full power on March 27. The unit achieved essentially 100 per cent operating capacity throughout most of 1984, except for required service inspections in April and May.

Under unit-participation power export contracts, United States utilities in New England purchase 230 MWe or 36 per cent of Point Lepreau I's total output; the remaining 400 MWe of low-cost power from Point Lepreau is used within the Province of New Brunswick.

On September 28, 1983, the federal and provincial Ministers of the Environment announced that a proposal for a second 600 MWe CANDU at Point Lepreau would undergo an environmental assessment review. The AECB had approved the Point Lepreau site, some 40 km southwest of Saint John, for two CANDU's of the 600 MWe design in 1974. It is envisaged that Point Lepreau II would produce electricity for the export market on a fully commercial basis.

In late 1982, Hydro-Québec's Gentilly 2 Nuclear Power Station near Bécancour went on-line. Difficulties with the station turbine were overcome, permitting the rescheduling of the in-service date of Canada's second 600 MWe CANDU to October 1, 1983.

CANDU's of the same size and design as those installed in New Brunswick and Quebec began operation during 1983 in the Republic of South Korea and Argentina; the in-service dates of the Wolsung and Cordoba reactors are December 28, 1983 and January 20, 1984, respectively.

On August 10, 1983, AECL announced that manufacturing orders would commence on the two-unit CANDU station in Romania. A substantial portion of the exterior construction for the two CANDU's has been completed by Romania and site preparation is in progress for a third unit.

## OUTLOOK

In the years ahead, the requirements for Canadian uranium will depend upon the growth of nuclear power capacity in Canada and its trading partners. Nuclear energy is already making a significant contribution to electricity requirements in many countries, and this installed nuclear capacity will require supplies of uranium well into the next century.

From data released by the IAEA it can be determined that total installed nuclear power capacity in the world increased by 10 per cent during 1983. Nuclear plants accounted for around 8 per cent of the world's total electrical generating capacity but, because they are generally used for base-load operation, nuclear units produced about 12 per cent of the world's electricity. This percentage breakdown held true for Canada in 1983.

By the year 2000, Canada's total installed nuclear capacity is expected to have grown to between 15 and 20 GWe, requiring approximately 2 500 tU per year. By that time, nuclear energy will be providing about 18 per cent of Canada's electricity supply; the level in Ontario alone will be over 60 per cent.

Since 1959, Canada has ranked second behind the United States in terms of world* uranium production. In 1983, Canada accounted for about 20 per cent of the world* total, which was estimated at some 37 000 tU; from the 1984 data available, it appears that Canada will replace the United States as the world's* leading producer. Although challenged by South Africa and Australia, Canada's position as the world's* leading exporter of uranium is expected to be maintained at least in the short term.

Canada's annual uranium production capability will expand to some 12 000 tU within the next year or two, reflecting the recent completion of projects in Ontario and the phasing in of committed development plans in Saskatchewan. Because of the bleak outlook for the uranium market over the next decade, it is unlikely that further new domestic production projects will be brought on-stream before the early 1990s. Actual production over the intervening period will be dependent on a number of factors, the most important of which will be delivery commitment levels and corporate decisions by individual companies concerning inventory accumulation. It is quite possible that production over the next few years will not match Canada's full 12 000 tU/year capability.

Whatever the magnitude of future uranium requirements turns out to be, Canada has the capability to provide for its own needs while maintaining its place among the leading suppliers of uranium to world markets.

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* World, as used here, excludes the U.S.S.R., Eastern Europe and the People's Republic of China.

* World, as used here, excludes the U.S.S.R., Eastern Europe and the People's Republic of China.

**TABLE 1. URANIUM PRODUCTION IN CANADA, BY COMPANY, 1982 AND 1983**

| Company | Location | Production 1982 | Production 1983 |
|---|---|---|---|
| | | tonnes U[1] | |
| Agnew Lake Mines Limited | Agnew Lake, Ont. | 65 | 15 |
| Cluff Mining (Amok Ltd/SMDC) | Cluff Lake, Sask. | 1 469 | 682 |
| Denison Mines Limited | Elliot Lake, Ont. | 2 359 | 2 298 |
| Eldorado Resources Limited | Eldorado, Sask.[2] | 282 | 1[3] |
| | Rabbit Lake, Sask. | 1 210[4] | 1 244 |
| Key Lake Mining Corporation | Key Lake, Sask. | - | 423[5] |
| Madawaska Mines Limited | Bancroft, Ont. | 153 | - |
| Rio Algom Limited - Quirke | Elliot Lake, Ont. | 1 672[6] | 1 446 |
| - Panel | | 865 | 831 |
| - Stanleigh | | - | 203[7] |
| Total Canada[8] | | 8 075 | 7 143 |

Source: Company annual reports.

[1] One metric ton (tonne) of elemental uranium (U), written as tU, is equivalent in terms of uranium content to 1.2999 short tons of uranium oxide ($U_3O_8$). [2] Beaverlodge operation only. [3] Final clean-up of product from precipitation circuit. [4] Joint operation - Gulf Minerals Canada Limited/Uranerz Canada Limited - acquired by Eldorado in October 1982. [5] Milling commenced in October 1983. [6] Does not include uranium recovered from Panel ore processed at Quirke, or from acid raffinate from Eldorado. [7] Milling commenced in July 1983. [8] Primary uranium production only; does not include uranium recovered from raffinates and sludges by Rio Algom and Denison, which during 1983 totalled some 20 tU.

**TABLE 2. OPERATIONAL CHARACTERISTICS OF CANADIAN URANIUM PRODUCTION CENTRES IN 1983**

| Company Name/ Production Centre | Nominal Mill Capacity/Actual Throughput (tonnes/day) | Total Ore Processed (tonnes) | Grade of Ore Processed (kgU/t) | Overall Mill Recovery (%) |
|---|---|---|---|---|
| Amok Ltd.-SMDC/ Cluff Lake | 100 in Phase I<br>(800 in Phase II) | see text | see text | 91 |
| Denison Mines Limited/ Elliot Lake | 13 610 / 9 612 | 3 191 079 | 0.77 | 93 |
| Eldorado Resources Limited/Rabbit Lake | 1 500 / 2 400 | 620 239 | 2.15 | 94 |
| Key Lake Mining Corporation/Key Lake* | 500-700/ NA | NA | NA | 95 |
| Rio Algom Limited/ Elliot Lake | | | | |
| - Quirke | 6 350 / 5 138 | 1 705 752 | 0.85 | 95 |
| - Panel | 2 990 / 3 010 | 987 215 | 0.89 | 95 |
| - Stanleigh* | 4 540 / 3 028 | 467 032 | 0.45 | 83 |

Sources: Corporate Annual Reports and the Atomic Energy Control Board (AECB).
* Mill tune-up and pre-operational testing during 1983. NA Not available.

TABLE 3. VALUE OF URANIUM SHIPMENTS[1] IN CANADA BY PROVINCE, 1982-84

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (t) | ($000) | (t) | ($000) | (t) | ($000) |
| Ontario | 5 092 | 589,057 | 4 767 | 546,306 | 4 381 | 538,733 |
| Saskatchewan | 2 551 | 248,411 | 2 056 | 121,366 | 5 312 | 377,561 |
| Total | 7 643 | 837,468 | 6 823 | 667,672 | 9 693 | 916,294 |

[1] Shipments of uranium (U) in concentrate from ore processing plants.
P Preliminary.

TABLE 4. WORK FORCE SUMMARY - CANADIAN URANIUM PRODUCING OPERATIONS

| Company Name (Mine Name) | Total Number of Employees (Mine, Mill, General) | | |
|---|---|---|---|
| | 1/1/81 | 1/1/83 | 1/1/84 |
| Agnew Lake Mines Limited (Agnew Lake) | 79 | 53 | - |
| Cluff Mining (Cluff Lake) | 241 | 304 | 272 |
| Denison Mines Limited (Denison) | 2,027 | 2,027 | 2,199 |
| Eldorado Resources Limited (Beaverlodge) | 845 | 120 | - |
| Key Lake Mining Corporation (Key Lake) | - | - | 489 |
| Gulf Minerals Canada Limited/ Uranerz Canada Limited (Rabbit Lake)* | 320 | 330 | 337 |
| Madawaska Mines Limited (Faraday) | 381 | 9 | - |
| Rio Algom Limited (Quirke) | 1,404 | 1,271 | 1,079 |
| (Panel) | 771 | 713 | 687 |
| (Stanleigh) | - | - | 789 |
| Total all producers | 6,068 | 4,827 | 5,845 |

* Acquired by Eldorado Resources Limited in October 1982.

## TABLE 5. PRODUCTION OF URANIUM IN CONCENTRATES BY MAJOR PRODUCING COUNTRIES, 1975-83

| | United States | Canada | South Africa | Namibia | France | Niger | Gabon | Australia | Other[1] | Total[2] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | (tonnes U) | | | | | |
| 1975 | 8 900 | 3 560 | 2 490 | - | 1 730 | 1 310 | 800 | - | 330 | 19 120 |
| 1976 | 9 800 | 4 850 | 2 760 | 650 | 1 870 | 1 460 | .. | 360 | 340 | 22 090 |
| 1977 | 11 500 | 5 790 | 3 360 | 2 340 | 2 100 | 1 610 | 910 | 355 | 385 | 28 350 |
| 1978 | 14 200 | 6 800 | 3 960 | 2 700 | 2 180 | 2 060 | 1 020 | 515 | 455 | 33 890 |
| 1979 | 14 400 | 6 820 | 4 800 | 3 840 | 2 360 | 3 620 | 1 100 | 705 | 465 | 38 110 |
| 1980 | 16 800 | 7 150 | 6 150 | 4 040 | 2 630 | 4 100 | 1 030 | 1 560 | 510 | 43 970 |
| 1981 | 14 800 | 7 720 | 6 130 | 3 970 | 2 560 | 4 360 | 1 020 | 2 920 | 670[3] | 44 150 |
| 1982 | 10 330 | 8 080 | 5 820 | 3 780 | 2 860 | 4 260 | 970 | 4 420 | 970[4] | 41 490 |
| 1983 | 8 140 | 7 140 | 6 060 | 3 800 | 3 240 | 3 420 | 1 040 | 3 220 | 1 020[4] | 37 110 |

Sources: Data derived principally from "Uranium: Resources, Production and Demand, December 1983, a biennial report jointly produced by the Nuclear Energy Agency of the Organization for Economic Co-operation and Development, and the International Atomic Energy Agency, with supplements from the annual "MINEMET" report of IMETAL SA, for 1981, and from miscellaneous sources, for 1982 and 1983. From 1980, country totals are rounded to the nearest 10 tU.

[1] Includes Argentina, Federal Republic of Germany, Japan, Portugal, Spain, and Sweden (1975 only). [2] Totals (rounded) are of listed figures only. [3] Includes Belgium, Brazil, India and Israel. [4] Includes Belgium and Brazil plus estimates for India and Israel.
- Nil; .. Not available.

## TABLE 6. ESTIMATES[a] OF CANADA'S URANIUM RESOURCES CONTAINED IN MINEABLE ORE[b], 1982, 1983

| Price ranges within which mineable ore is assessed[c] | Reasonably Assured Resources | | | | Estimated Additional Resources - Category I | |
|---|---|---|---|---|---|---|
| | (Measured) | | (Indicated) | | (Inferred) | |
| (Canadian dollars) | 1983[d] | 1982[e] | 1983[d] | 1982[e] | 1983[d] | 1982[e] |
| | | | ('000 tonnes U) | | | |
| A | 30 | 35 | 162 | 150 | 141 | 191 |
| B | - | 1 | 41 | 9 | 78 | 50 |
| A + B | 30 | 36 | 203 | 159 | 219 | 241 |
| C | 27 | 28 | 48 | 46 | 64 | 63 |
| A + B + C | 57 | 64 | 251 | 205 | 283 | 304 |

[a] Interim revisions for 1983; comprehensive assessments for selected properties only.
[b] Milling losses have not been deducted; uranium recoverable from such ore will be less.
[c] The price figures reflect the price of a quantity of uranium concentrate containing 1 kg of elemental uranium. The prices were used in determining the cut-off grade at each deposit assessed, taking into account the mining method used in the milling losses expected.
[d] For the 1983 assessment, the price ranges were (A) $100/kg U or less, (B) between $100 and $150/kg U, and (C) between $150 and $300/kg U.
[e] For the 1982 assessment, the price ranges were (A) $115/kg U or less, (B) between $115 and $170/kg U, and (C) between $170 and $340/kg U.
[f] Only the resources mineable within the lower two price ranges (A and B) are used for the purpose of ensuring that sufficient uranium is reserved to meet domestic requirements.
- Nil.

## TABLE 7. URANIUM UNDER EXPORT CONTRACTS REVIEWED[1] SINCE SEPTEMBER 5, 1974

| Country of buyer | 1983 | 1984 |
|---|---|---|
| | (tonnes U) | |
| Belgium | 3 030 | 3 030 |
| Finland | 2 200 | 3 510 |
| France | 9 390 | 9 390 |
| Italy | 1 120 | 1 120 |
| Japan | 22 680 | 22 740 |
| South Korea | 5 140 | 5 140 |
| Spain | 4 040 | 3 940 |
| Sweden | 4 960 | 5 310 |
| Switzerland | 150 | 150 |
| United Kingdom | 7 700 | 7 700 |
| United States | 28 670 | 30 360 |
| West Germany | 11 480 | 11 580 |
| Total | 100 560 | 103 970 |

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[1] Reviewed and accepted under Canadian uranium export policy. Totals adjusted to reflect new and amended contracts as of December of given year.

## TABLE 8. EXPORTS OF URANIUM OF CANADIAN ORIGIN

| Country of Final Destination | Tonnes of contained uranium* | |
|---|---|---|
| | 1982 | 1983 |
| Belgium | 85 | - |
| Finland | 97 | 179 |
| France | - | 435 |
| Italy | 143 | - |
| Japan | 718 | 663 |
| South Korea | 74 | 94 |
| Spain | 110 | - |
| Sweden | 889 | 612 |
| United Kingdom | 379 | 674 |
| United States | 4 852** | 672 |
| West Germany | 471 | 490 |
| Total | 7 818 | 3 819 |

Source: The Atomic Energy Control Board.

* Some of this uranium was first exported to intermediate countries, namely France, USA and USSR, for enrichment and then forwarded to the country of final destination.
** The bulk of this material represents concentrates exchanged by Eldorado in the purchase of the Rabbit Lake operation.

## TABLE 9. EXPORTS[1] OF RADIOACTIVE ORES AND CONCENTRATES[2] FROM CANADA, 1976-83

| | United States[3] | U.S.S.R. | United Kingdom | Italy | France | Japan | Norway | South Korea | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | ($000) | | | | |
| 1976 | 46,850 | - | 20,541 | - | - | - | - | - | 67,392 |
| 1977 | 72,848 | - | 2,590 | - | - | - | - | - | 75,438 |
| 1978 | 163,911 | - | 39,106 | 3,348 | - | 791 | - | - | 207,156 |
| 1979 | 347,388 | - | 18,851 | 12,613 | - | 9 | - | - | 378,862 |
| 1980 | 218,013 | - | 10,319 | - | 1 | - | - | 2,329 | 230,662 |
| 1981 | 152,473 | 3,182 | 18,845 | - | - | - | 2,862 | 2,022 | 179,384 |
| 1982 | 346,891 | - | 11,690 | - | - | - | - | - | 358,581 |
| 1983 | 25,400 | - | 37,175 | - | - | - | - | - | 62,575 |

Source: Statistics Canada.
[1] Material that cleared Canadian customs with destination as indicated. [2] Includes uranium in concentrates. [3] For 1976, uranium almost entirely destined for transshipment, primarily to western Europe and Japan, following conversion and enrichment; for subsequent years, figures represent a mixture of sales to U.S. and others, primarily in western Europe and Japan.
- Nil.

## TABLE 10. EXPORTS[1] OF RADIOACTIVE ELEMENTS[2] AND ISOTOPES FROM CANADA, 1976-83

| | United States[3] | U.S.S.R.[4] | UK | West Germany | France | Belgium Luxembourg | Netherlands | Finland | Argentina | Japan | South Korea | Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | ($000) | | | | | | |
| 1976 | 151,427 | 24,471 | 3,786 | 288 | 375 | - | - | - | 84 | 1,068 | - | 4,198 | 185,697 |
| 1977 | 151,869 | 6,133 | 356 | 384 | 685 | 75 | - | 10 | 287 | 288 | - | 1,078 | 161,165 |
| 1978 | 269,903 | 101,619 | 38,602 | 6,918 | 19,046 | 23 | - | 10 | 12,177 | 1,017 | - | 1,668 | 450,983 |
| 1979 | 293,577 | 170,500 | 5,147 | 26,159 | 1,762 | 221 | 629 | 5,493 | 94,038 | 1,101 | 87 | 3,363 | 602,077 |
| 1980 | 199,001 | 77,235 | 2,104 | 20,406 | 144,013 | 4,847 | 374 | 6,408 | 27,766 | 1,911 | 137,002 | 4,312 | 625,379 |
| 1981 | 382,418 | 20,192 | 2,081 | 40,092 | 213,051 | 339 | 7,506 | - | 248 | 1,577 | 67 | 2,915 | 670,486 |
| 1982 | 299,246 | 34,854 | 796 | 37,250 | 36,213 | 291 | - | 199 | 214 | 19,617 | 123 | 5,230 | 434,033 |
| 1983 | 261,168 | 8,148 | 2,303 | 32,208 | 39,037 | 232 | 1,517 | 11 | 315 | 12,371 | 3,057 | 7,248 | 367,615 |

Source: Statistics Canada.
[1] Material that cleared Canadian customs with destination as indicated. [2] Includes uranium hexafluoride ($UF_6$) and radioisotopes for medical and industrial purposes. [3] For year 1976, $UF_6$ component destined for transshipment, primarily to western Europe and Japan, following enrichment; for subsequent years, figures would also include $UF_6$ sales to the U.S. market. [4] $UF_6$ component destined entirely for transshipment to western Europe, following enrichment.
- Nil.

### TABLE 11. NUCLEAR SHARE OF ELECTRICITY PRODUCTION IN SELECTED COUNTRIES IN 1983

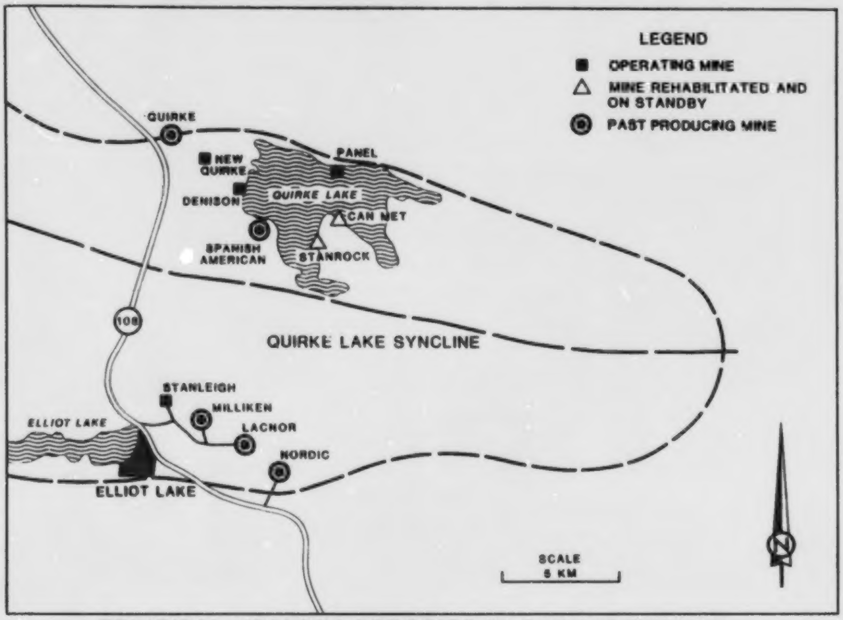
| | % |
|---|---|
| France | 48.3 |
| Belgium | 45.9 |
| Finland | 41.5 |
| Sweden | 36.9 |
| Taiwan | 37* |
| Bulgaria | 32.3 |
| Switzerland | 29.3 |
| Republic of Korea | 18.4 |
| Japan | 18* |
| Federal Republic of Germany | 17.8 |
| United Kingdom | 17.0 |
| Canada | 12.9 |
| United States | 12.6 |
| German Democratic Republic | 12 |
| Hungary | 10* |

Source: International Atomic Energy Agency.
* Estimate as no official data provided.

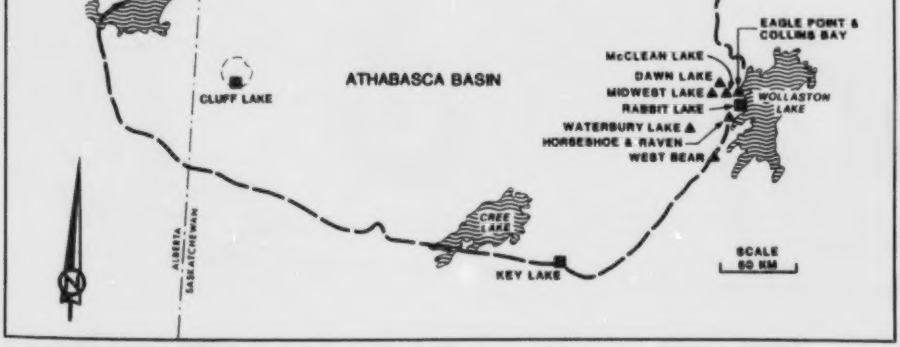
### TABLE 12. NUCLEAR POWER PLANTS IN CANADA, DECEMBER 1984

| Reactors | Owner | Net Output (MWe) | In-Service Dates (Expected) |
|---|---|---|---|
| Nuclear Power Demonstration | Atomic Energy of Canada Limited | 22 | 1962 |
| Pickering 1 to 4 | Ontario Hydro | 2 060 | 1971-73 |
| Bruce 1 to 4 | Ontario Hydro | 2 960 | 1977-79 |
| Point Lepreau | New Brunswick Electric Power Commission | 635 | 1983 |
| Gentilly 2 | Hydro-Québec | 638 | 1983 |
| Pickering 5 and 6 | Ontario Hydro | 1 032 | 1983-84 |
| Pickering 7 and 8 | Ontario Hydro | 1 032 | (1984-85) |
| Bruce 6 | Ontario Hydro | 750 | 1984 |
| Bruce 5, 7 and 8 | Ontario Hydro | 2 250 | (1985-87) |
| Darlington 1 to 4 | Ontario Hydro | 3 524 | (1988-92) |
| Total net output expected by 1993 | | 14 903 MWe | |

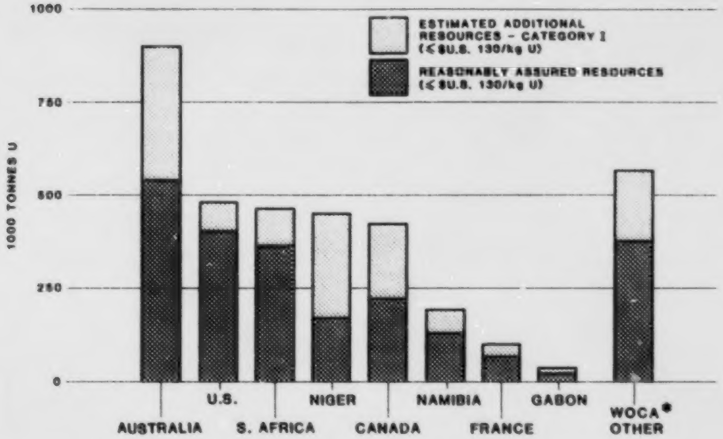
## ELLIOT LAKE ONTARIO, PRODUCING DISTRICT


LEGEND
■ OPERATING MINE
△ MINE REHABILITATED AND ON STANDBY
◎ PAST PRODUCING MINE
QUIRKE
NEW QUIRKE
PANEL
DENISON
QUIRKE LAKE
CAN MET
SPANISH AMERICAN
STANROCK
108
QUIRKE LAKE SYNCLINE
STANLEIGH
MILLIKEN
LACNOR
ELLIOT LAKE
NORDIC
ELLIOT LAKE
SCALE
5 KM
N

## PRINCIPAL URANIUM DEPOSITS IN SASKATCHEWAN


LEGEND
■ OPERATING OR COMMITTED MINE
◎ PAST PRODUCING MINE
▲ URANIUM DEPOSIT
URANIUM CITY
BEAVERLODGE
MAURICE BAY
LAKE ATHABASCA
FOND-DU-LAC
EAGLE POINT & COLLINS BAY
McCLEAN LAKE
DAWN LAKE
MIDWEST LAKE
RABBIT LAKE
WATERBURY LAKE
HORSESHOE & RAVEN
WEST BEAR
WOLLASTON LAKE
ATHABASCA BASIN
CLUFF LAKE
CREE LAKE
KEY LAKE
ALBERTA
SASKATCHEWAN
SCALE
50 KM
N

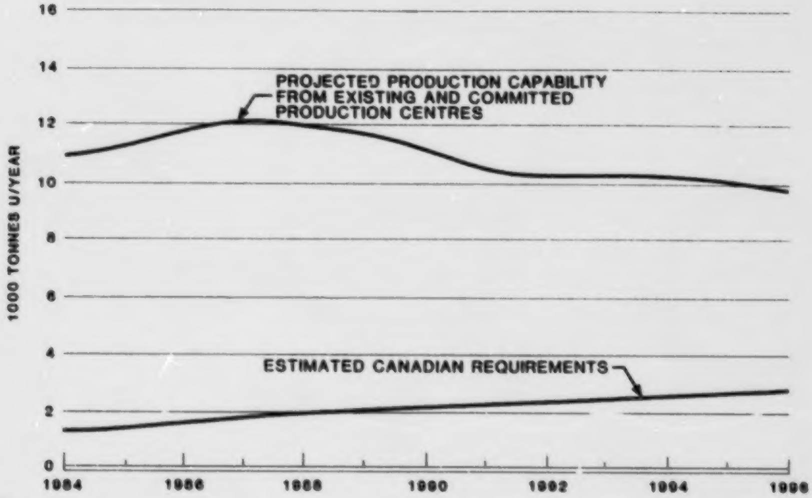
## DISTRIBUTION OF URANIUM RESOURCES AMONG PRINCIPAL PRODUCING COUNTRIES



SOURCE : NEA/IAEA DECEMBER 1983 "REDBOOK"
PLUS 1984 REVISIONS FOR AUSTRALIA, U.S., NIGER AND CANADA

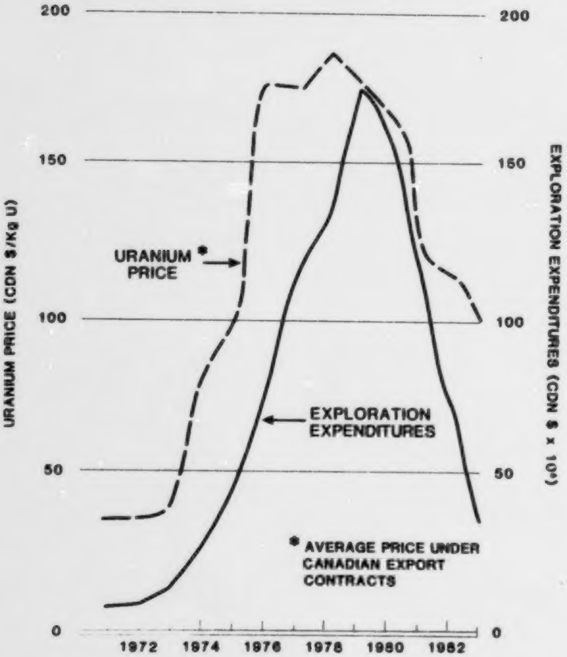
* WORLD OUTSIDE CENTRALLY PLANNED-ECONOMY AREAS

## PROJECTED CANADIAN PRODUCTION CAPABILITY COMPARED WITH ESTIMATED ANNUAL URANIUM REQUIREMENTS



## RESPONSIVENESS OF URANIUM EXPLORATION EXPENDITURES IN CANADA TO URANIUM PRICE MOVEMENTS, 1971-1983

CONSTANT CDN $ 1983



* AVERAGE PRICE UNDER CANADIAN EXPORT CONTRACTS

# Zinc

**M.J. GAUVIN**

With the recovery in the world economy from the deep recession of 1981-82, improved market conditions for zinc began during the second half of 1983 and continued during the first half of 1984. Demand and prices then declined and producers were forced to continue evaluating the effects of their production decisions on the marketplace.

## CANADIAN DEVELOPMENTS

### Mining

Canadian zinc mine production increased sharply during 1984 to an estimated 1 213 000 t from the 1 069 709 t produced in 1983, an increase of 13.4 per cent.

Production at the Buchans, Newfoundland copper-lead-zinc mine of Abitibi-Price Inc. (51 per cent) and ASARCO Incorporated (49 per cent) ceased permanently in September, because of exhaustion of ore reserves. The fifty-six year old mine had discontinued production in December 1981 but reopened in July 1983 to salvage the remaining reserves in its deepest levels. Normal production was maintained throughout the year at the Daniel's Harbour mine of Newfoundland Zinc Mines Limited. Diamond drilling in the mine area discovered two new ore zones which will be further evaluated by underground exploration from the main L-Zone workings.

At Brunswick Mining and Smelting Corporation Limited's No. 12 mine near Bathurst, production was at slightly higher rates than in previous years. Heath Steele Mines Limited and ASARCO Incorporated have not operated their Little River Joint Venture mine located near Newcastle since April 1983, but during 1984 some production was obtained from a new open-pit on the property.

In October Noranda Mines and Les Mines reopened the Gallen zinc-precious metal mine near Noranda. Production at the Gallen had been suspended since July 1982.

Corporation Falconbridge Copper started a shaft-sinking and exploration program on the Ansil deposit which is located close to the plant of its Lake Dufault operations near Noranda, Quebec. The company is also proceeding with the sinking of a 510 m shaft at its Winston Lake deposit near Schreiber, Ontario. The property, under option from Zenmac Explorations Limited, has ore reserves estimated at 2.7 million t averaging 17.8 per cent zinc, 0.95 per cent copper, 0.74 oz silver and 0.025 oz gold per t. Underground development and diamond drilling will follow the initial shaft-sinking.

In early 1984 Sherritt Gordon Mines Limited announced the closure of the Ruttan copper-zinc mine in northern Manitoba, but reconsidered and authorized continued operations after it experienced improved productivity and received a $10 million project loan from the Manitoba government, for a development program at depth. Sherritt placed increased emphasis on zinc production at both its Ruttan and Fox mines. The Fox is expected to close late in 1985 because of depletion of ore reserves.

In British Columbia, Noranda Mines suspended operations in April, 1984 at its Goldstream property near Revelstoke. This new mine started production in the first half of 1983. Westmin Resources resumed production in April after a 4½ month strike at its Myra Falls operations, and continued to work towards bringing its nearby H-W mine into production. A new 2 700 tpd mill will process ore from the company's mines and production of zinc in concentrates is expected to increase by 30 000 tpd early in 1985.

In the Yukon, production is still suspended at the Faro lead-zinc mine of Cyprus Anvil Mining Corporation. A two-year overburden stripping program

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begun in June 1983, with financial assistance from the Yukon territorial and federal governments, is continuing. In the far north, the Polaris zinc-lead mine of Cominco Ltd. on Little Cornwallis Island was closed for one month starting in mid-December 1984, because of low zinc prices. The Polaris mine has an annual capacity of 100 000 t of zinc and 30 000 t of lead in concentrates.

**Smelting and Refining**

Refined zinc production in Canada estimated at 683 000 t in 1984, is an all-time high, and up considerably from the 617 033 t produced in 1983. Canadian Electrolytic Zinc Limited (CEZ) started operating its new zinc roaster at Valleyfield, Quebec in September 1983. The facility allows CEZ to roast all its zinc concentrates at the plant. It also raised refined zinc capacity by 9 000 t to 227 000 t. Kidd Creek Mines during 1983 completed a 19 000 t expansion of its zinc facility at Timmins, Ontario raising annual capacity to 127 000 t. The expansion included a pressure leaching plant similar to that installed by Cominco Ltd. at Trail, British Columbia. Kidd Creek is now in the process of adding an additional 7 000 t of capacity which is expected to be in operation in 1986.

**Consumption**

Canadian consumption of refined zinc, as measured by domestic shipments, was estimated at 141 600 t in 1984 compared with 134 424 t in 1983. However, in addition to metal received from Canadian producers, consumers imported almost 10 000 t of zinc from foreign producers during 1983.

## WORLD DEVELOPMENTS

**Mining**

Non-socialist world zinc mine production in 1984 is estimated at 5.0 million t, a 4.6 per cent increase from the 4.79 million t produced in 1983. Large increases in production in Canada and Spain more than offset small decreases in Australia and the United States. During 1984, seven zinc mines were opened or expanded which increased capacity by 152 000 t. Most of the increase was accounted for by mines in Thailand and Mexico. Three mine closures or suspensions of production were reported, two of these in Canada. During 1983, seventeen zinc mines were opened or expanded which increased total annual capacity by about 280 000 t of zinc. Half of this increase was in Australia. Closures in Canada and the United States, mainly through suspensions, totalled about 225 000 t of annual capacity in 1983.

United States mine production in 1984 was estimated to have fallen slightly as a result of strikes at the lead-zinc mines in Missouri. The permanent closure of the Friedenville mine in Pennsylvania in late 1983 was largely offset by the reopening of Inspiration's Beaver Creek Mine in Tennessee and the opening of St. Joe's Viburnum No. 35 in Missouri. ASARCO resumed development of its West Fork lead-zinc mine in Missouri, which is expected to start producing in 1985 with a capacity of 7 000 tpy of zinc in concentrates. Cominco American Incorporated completed feasibility studies for a joint venture with Nana Regional Corp., an Alaskan native company, to develop the Red Dog zinc-lead-silver deposit in northwest Alaska. Located some 100 km from the Chukchi Sea, ore reserves are estimated at 85 million t with grades of 17.1 per cent zinc, 5.0 per cent lead and 74 g/t of silver. This large project is expected to come on-stream in the late 1980s. It will be operated and financed by Cominco and after the investment is recovered, the partners will eventually share proceeds on a 50:50 basis.

Mexican zinc production was at a new high of 300 000 t in 1984. Industrial Minera Mexico S.A. completed the expansion of its San Martin mine which added 45 000 tpy to its capacity. In 1983, the company doubled the capacity of its Santa Barbara zinc-lead-silver underground mine to 48 000 tpy of zinc in concentrates. An additional 68 000 t of zinc mine capacity is expected to come on-stream in Mexico in the next four years. In Peru, three mine expansions will bring an additional 30 000 t of mine capacity on-stream in 1985.

Bula Mines Ltd. announced plans to bring its Navan, Ireland zinc-lead deposit into production in 1987. The mine will have a capacity of 55 000 tpy of zinc in concentrates. In Italy, SAMIM S.p.A. of Italy is in the process of expanding its Montiponi lead-zinc mine, which will increase the mine's zinc capacity by 42 000 t in 1986. Minas De Almagrera has increased the capacity of the Sotiel mine in Spain by 6 000 tpy and Austuriana de Zinc is proceeding with an expansion of its Reocin lead-zinc mine which will add 20 000 t to its capacity in 1985. Two small expansions in Yugoslavia added 7 000 t to the country's zinc mine capacity.

The main development in Australia in 1983 was the opening, by EZ Industries Ltd., of the large Elura mine in New South Wales. This $A 200 million underground mining project has a capacity to produce 70 000 t of zinc and 40 000 t of lead in concentrates. MIM Holdings Limited completed the expansion of its Mt. Isa, Queensland mine. Capacity increased by 65 000 tpy to 175 000 tpy of zinc in concentrates.

Strikes in Australia reduced 1984 zinc mine production to a little below the 1983 level. MIM Holdings is continuing development of the Hilton zinc-lead-silver mine with trial stoping scheduled for 1985. This project is required to maintain production levels at the Mt. Isa complex. Exploration continued at the Woodcutters zinc-lead-silver deposit in the Northern Territory, which is scheduled to start producing in 1985 with a capacity of 23 000 tpy of zinc. The Mae Sot zinc mine of Padaeng Industry in Thailand, which came into production in March in preparation for the opening of the new zinc smelter, has a capacity of 60 000 tpy of zinc. Hindustan Zinc Inc. is considering bringing the large Rampura-Agucha zinc deposit into production in 1989 at a rate of 70 000 tpy of zinc in concentrates. With this additional tonnage, India will become almost self-sufficient in zinc.

### Smelting and Refining

Non-socialist world zinc metal production was estimated at 4.8 million t in 1984, or 3.8 per cent above the 1983 level. All principal producing countries except Australia recorded substantial increases over 1983. Total output in 1984 was at a record level, well above the previous peak of 4.71 million t in 1979.

ASARCO Inc. reopened its Corpus Christi, Texas plant in May. Production at the 104 000 tpy plant had been suspended since October 1982. It was operating at 50 per cent of capacity prior to the closure. Gulf and Western Industries sold its 60 per cent interest in Jersey Minière Zinc to its Belgium partner, a subsidiary of Union Minière. Jersey Minière operates a zinc mining and refining complex at Clarksville,

Gulf and Western Industries sold its 60 per cent interest in Jersey Minière Zinc to its Belgium partner, a subsidiary of Union Minière. Jersey Minière operates a zinc mining and refining complex at Clarksville,

Tennessee. The acquisition by St. Joe Minerals Corp. of National Zinc Co. resulted in the creation of the largest Unites States zinc producing company with a capacity of 142 000 tpy. National operates a 51 000 t electrolytic refinery in Bartlesville, Oklahoma while St. Joe has long operated an electrothermic plant at Monaco, Pennsylvania where a 14 000 t expansion has just been completed, raising its capacity to 91 000 tpy.

Electrolytic Zinc Company of Australasia Ltd. completed a small 4 000 t expansion of its Risdon refinery, bringing its capacity up to 214 000 t. In Thailand, Padaeng Industry started production in late 1984 at its new 60 000 t electrolytic refinery.

European zinc producers in 1983 received approval from the EC Commission for a capacity shutdown agreement, whereby companies would be paid for each tonne of zinc smelting capacity permanently closed. As no nominations for closure were received by the Commission, the agreement expired. It had been anticipated that up to 200 000 tpy capacity would be nominated for closure and the industry hoped that this concerted action would reverse the series of financial losses most companies had been experiencing. Rather than reducing capacity, expansions and a new plant will add 163 000 tpy capacity in Europe in the next two years. SAMIM S.p.A. is building a new 83 000 t electrolytic plant at Porto Vesme, Sardinia. Expansions of 20 000 t are under way by Pertusola at Crotone, Italy, and by Norzink at Odda, Norway, while in Yugoslavia, Trepca is adding 40 000 t capacity to its Kosovska Mitrovica refinery.

In India, Cominco-Binani is expanding its electrolytic plant by 6 000 t in 1987. Iran has announced the start of construction in the northern part of the country of a metallurgical plant expected to produce about 60 000 t of lead and 40 000 t of zinc towards the end of this decade. The Zinc Corporation of South Africa Ltd. completed in 1983 the 20 000 t expansion of its zinc electrolytic plant at Springs. This brought its total capacity to 105 000 t.

### Consumption

World zinc metal consumption in 1984 was estimated at 4.7 million t, up 96 000 t from 1983. The peak level of consumption in the non-socialist world was 4.88 million t in 1973.

## PRICES

At the beginning of 1983, the price of high grade zinc was 40¢ (U.S.) in the United States while the European producer price (EPP) was split at $US 800-850/t. Prices reached their low point in March when the U.S. price averaged 37.9¢ and the EPP was $750. Periodic price increases, the last in late December brought the producer price for high grade zinc up to 49¢/lb in the United States, 60¢ in Canada and $980/t outside North America. A similar price pattern prevailed on the LME where at the end of the year, zinc traded at £617.5 a t.

Early in January, 1984, the U.S. producer price was raised to 51¢ for high grade and the EPP moved up to $1,010 and then to $1,050 at the end of the month. A further increase in March brought the U.S. price of high grade up to 53¢ and in Canada it was quoted at 67¢/lb, their highest prices for the year. During April and part of June most producers quoted their EPP at $1,090 a t but a split price prevailed as Preussag and Metallgesellschaft maintained their $1,050 quote. At the end of June the EPP was lowered to $1,040 a t and the U.S. producer price of high grade dropped to 51 and then 50¢/lb. A further reduction of the EPP to $990 in mid-July was followed in early August by a lowering of the United States and Canadian producer prices of high grade to 48¢ and 62½¢, respectively. In early September the EPP was lowered to $940 a t and later in the month the U.S. producer price for high grade dropped to 45¢/lb. The price in Canada was 59½¢/lb. During the first week of October the EPP was lowered further, to $900 (U.S.) a t, which was maintained until the end of the year.

On September 3, the LME introduced a new zinc contract based on metal with a minimum purity of 99.95 per cent (high grade). This new contract will run concurrently with the old contract until the end of November 1985 when the old g.o.b. contract will be terminated.

## OTHER DEVELOPMENTS

Zinc usage in zinc diecast parts in the average North American built automobile has been declining over the years due to the increased use of thin wall zinc castings and competition from plastic parts, both in response to the demand for lighter-weight cars. The weight of zinc diecastings per car has dropped from almost 22.7 kilos in 1970 to 11.4 kilos in 1980 but appears to have levelled out at about 10.5 kilos in currently built vehicles. The strong demand for a better rust-resistant automobile has resulted in increased usage of galvanized steel and zinc consumption in galvanized iron for automobiles is expected to almost double in 1990 from the 55 000 t used in 1983.

The first copper-plated zinc penny was struck by the U.S. Mint in November 1981 and placed in circulation in January 1982. The penny blanks are made of an alloy containing 99.2 per cent SHG zinc and 0.8 per cent copper; the total penny including plating is 97.6 per cent zinc and 2.4 per cent copper. This new usage for zinc now consumes about 40 000 tpy of zinc and other countries are considering converting to this form of coinage. The regular tenders conducted by the Mint are looked upon by many merchants and producers as a barometer of the zinc market.

Galfan, a new and improved galvanizing alloy developed by the International Lead Zinc Research Organization, Inc. (ILZRO) was first used commercially in 1983 in Japan. The alloy contains about 95 per cent zinc, five per cent aluminum and a small but significant amount of rare earth metals. The new alloy outperforms conventional galvanizing and Galvalume in corrosion resistance and several other characteristics. Another advantage is that only minor modifications are necessary to adapt existing galvanizing lines compared with the major cost of converting a line for Galvalume. Galvalume, a 55 per cent aluminum, 43.4 per cent zinc and 1.6 per cent silicon alloy, developed by Bethlehem Steel Corporation was introduced to the U.S. market in 1976 and is being used in specialized applications.

These alloys are complementary to galvanizing and increase the potential market for zinc.

## OUTLOOK

Overcapacity in all sectors of the industry is expected to persist until at least the end of the decade. At the same time the industry's need to remain competitive will require a close balance between supply and demand. This implies a further reduction of costs and a low level of inventory. Pressure on prices will continue and prices are expected to change little in constant dollar terms at least until overcapacity in all segments of the industry has been worked off. Any substantial upturn in the world economy, particularly in the key construction and automobile industries would result in improved demand and would increase real prices for a wide range of zinc mineral products.

## TARIFFS

(% unless otherwise specified)

CANADA

| Item No. | | British Preferential | Most Favoured Nation | General | General Preferential |
|---|---|---|---|---|---|
| 32900-1 | Zinc in ores and concentrates | free | free | free | free |
| 34500-1 | Zinc dross and zinc scrap for remelting, or for processing into zinc dust | free | free | 10 | free |
| 34505-1 | Zinc spelter, zinc and zinc alloys containing not more than 10% by weight of other metal or metals, in the form of pigs, slabs, blocks, dust or granules | free | free | 2¢/lb | free |
| 35800-1 | Zinc anodes | free | free | 10 | free |

UNITED STATES (MFN)

| Item No. | | Most Favoured Nation |
|---|---|---|
| 626.04 | Zinc, unwrought, alloyed | 19.0% |

(% unless otherwise specified)

| | | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|
| 602.20 | Zinc in ores and concentrates | 0.48¢/lb | 0.44¢/lb | 0.39¢/lb | 0.35¢/lb | 0.30¢/lb |
| 626.02 | Zinc, unwrought, unalloyed | 1.8 | 1.7 | 1.6 | 1.6 | 1.5 |
| 626.10 | Zinc, waste and scrap (suspended until June 30, 1984) | 3.7 | 3.3 | 2.9 | 2.5 | 2.1 |

EUROPEAN ECONOMIC COMMUNITY (MFN)

(% unless otherwise specified)

| | | Base Rate | Concession Rate |
|---|---|---|---|
| 26.01 | Zinc, ores and concentrates | free | free |
| 79.01 | Zinc, unwrought | 3.5 | 3.5 |
| | Zinc, waste and scrap | free | free |

JAPAN (MFN)

(% unless otherwise specified)

| | | 1983 | Base Rate | Concession Rate |
|---|---|---|---|---|
| 26.01 | Zinc, ores and concentrates | free | free | free |
| 79.01 | Zinc, unwrought, unalloyed | 2.3 | 2.5 | 2.1 |
| | Zinc, unwrought, alloyed | 7.5 yen/kg | 10 yen/kg | 7 yen/kg |
| | Zinc, waste and scrap | 1.9 | 2.5 | 1.9 |

Sources: The Customs Tariff, 1983, Revenue Canada, Customs and Excise; Tariff Schedules of the United States Annotated 1983, USITC Publication 1317; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 25, No. L 318, 1982; Customs Tariff Schedules of Japan, 1983.

TABLE 1. CANADA, ZINC PRODUCTION AND TRADE, 1982-84 AND CONSUMPTION 1981 and 1982

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| **Production** | | | | | | |
| All forms[1] | | | | | | |
| Ontario | 260 544 | 279,563 | 288 528 | 331,605 | 294 237 | 413,991 |
| New Brunswick | 230 299 | 247,110 | 225 054 | 258,655 | 246 424 | 346,719 |
| Northwest Territories | 213 523 | 229,110 | 234 883 | 269,951 | 245 357 | 345,217 |
| British Columbia | 75 183 | 80,671 | 95 289 | 109,516 | 92 619 | 130,315 |
| Manitoba | 31 435 | 33,730 | 49 007 | 56,324 | 48 564 | 68,330 |
| Quebec | 67 002 | 71,893 | 53 688 | 61,703 | 48 900 | 68,802 |
| Newfoundland | 28 139 | 30,194 | 35 358 | 40,637 | 39 910 | 56,153 |
| Saskatchewan | 4 945 | 5,306 | 5 879 | 6,757 | 6 043 | 8,503 |
| Yukon | 54 537 | 58,519 | 27 | 30 | - | - |
| Total | 965 607 | 1,036,096 | 987 713 | 1,135,178 | 1 022 054 | 1,438,030 |
| Mine output[2] | 1 189 129 | .. | 1 069 709 | .. | 1 213 000 | .. |
| Refined[3] | 511 870 | .. | 617 033 | .. | 683 000 | .. |
| | | | | | (Jan.-Sept. 1984) | |
| **Exports** | | | | | | |
| Zinc blocks, pigs and slabs | | | | | | |
| United States | 263 588 | 266,028 | 309 490 | 328,684 | 251 086 | 343,177 |
| People's Republic of China | 21 495 | 20,289 | 54 244 | 45,255 | 14 688 | 17,135 |
| United Kingdom | 44 692 | 42,708 | 25 697 | 23,454 | 29 755 | 36,562 |
| Taiwan | 9 855 | 9,140 | 16 231 | 13,791 | 9 703 | 11,289 |
| Philippines | 10 877 | 9,876 | 9 397 | 7,760 | 5 140 | 5,710 |
| Hong Kong | 2 778 | 2,714 | 8 486 | 7,404 | 6 645 | 8,218 |
| West Germany | 12 021 | 11,588 | 6 197 | 5,751 | 7 380 | 8,844 |
| Indonesia | 11 192 | 10,129 | 6 422 | 5,393 | 4 502 | 5,390 |
| Italy | 5 926 | 5,210 | 5 059 | 4,301 | 5 682 | 5,886 |
| Singapore | 7 572 | 7,049 | 6 092 | 5,096 | 3 566 | 3,936 |
| New Zealand | 6 905 | 7,306 | 5 560 | 4,960 | 6 300 | 7,519 |
| Other countries | 73 489 | 67,623 | 47 568 | 41,709 | 35 673 | 41,310 |
| Total | 470 390 | 459,660 | 500 443 | 493,558 | 380 120 | 494,976 |
| Zinc contained in ores and concentrates | | | | | | |
| Belgium-Luxembourg | 214 056 | 98,249 | 344 672 | 139,853 | 239 159 | 116,001 |
| West Germany | 30 563 | 12,975 | 113 698 | 30 287 | 25 213 | 10,908 |
| Japan | 83 748 | 32,352 | 47 817 | 21,403 | 51 917 | 28,738 |
| Italy | 9 859 | 5,336 | 23 355 | 15,190 | 4 110 | 2,170 |
| France | 18 086 | 11,133 | 30 191 | 14,934 | 16 702 | 11,465 |
| Yugoslavia | - | - | 22 826 | 8,707 | .. | .. |
| United Kingdom | 34 602 | 20,271 | 17 660 | 8,497 | 11 644 | 6,275 |
| United States | 4 953 | 2,553 | 8 939 | 6,639 | 19 462 | 14,402 |
| Finland | 12 305 | 4,230 | 10 478 | 5,492 | .. | .. |
| Other countries | 49 579 | 30,109 | 41 156 | 21 216 | 15 999 | 11,059 |
| Total | 457 751 | 217,208 | 660 792 | 272,218 | 384 206 | 201,018 |
| Zinc alloy scrap, dross and ash[4] | | | | | | |
| United States | 10 155 | 4,714 | 12 541 | 6,003 | 7 021 | 5,555 |
| United Kingdom | 7 992 | 4,699 | 2 549 | 858 | 1 209 | 446 |
| West Germany | 7 048 | 2,889 | 1 610 | 310 | 6 097 | 2,805 |
| Japan | 34 | 16 | 392 | 204 | 136 | 88 |
| Belgium-Luxembourg | 22 996 | 13,831 | 194 | 85 | 266 | 200 |
| Other countries | 25 364 | 15,313 | 643 | 273 | 1 320 | 1,083 |
| Total | 73 589 | 41,462 | 17 929 | 7,733 | 16 049 | 10,177 |

**TABLE 1.** (cont'd.)

| | 1982 | | 1983 | | 1984P | |
|---|---|---|---|---|---|---|
| | (tonnes) | ($000) | (tonnes) | ($000) | (tonnes) | ($000) |
| Zinc dust and granules | | | | | | |
| United States | 2 296 | 3,061 | 4 090 | 4,602 | 2 379 | 3,714 |
| Colombia | 14 | 22 | 169 | 272 | 28 | 41 |
| United Kingdom | - | - | 128 | 90 | .. | .. |
| Other countries | 1 | 2 | 28 | 55 | 112 | 76 |
| Total | 2 311 | 3,085 | 4 415 | 5,019 | 2 519 | 3,831 |
| Zinc fabricated material, nes | | | | | | |
| United States | 1 020 | 2,925 | 1 762 | 3,734 | 669 | 2,167 |
| Chile | - | - | 80 | 74 | .. | .. |
| France | 18 | 60 | 24 | 69 | .. | .. |
| Hong Kong | 9 | 59 | 74 | 67 | .. | 2 |
| Taiwan | - | - | 35 | 31 | - | - |
| Other countries | 49 | 83 | 16 | 62 | 104 | 561 |
| Total | 1 096 | 3,127 | 1 991 | 4,037 | 773 | 2,730 |
| **Imports** | | | | | (Jan.-Sept. 1984) | |
| In ores, concentrates and scrap | 29 492 | 15,038 | 78 100 | 37,155 | 34 778 | 21,851 |
| Dust and granules | 616 | 875 | 445 | 669 | 522 | 966 |
| Slabs, blocks, pigs and anodes | 689 | 753 | 9 964 | 10,845 | 4 646 | 6,293 |
| Bars, rods, plates, strip and sheet | 298 | 786 | 575 | 1,226 | 317 | 857 |
| Slugs, discs and shells | 211 | 128 | 58 | 48 | 13 | 14 |
| Zinc oxide | 1 367 | 1,604 | 1 257 | 1,313 | 926 | 1,020 |
| Zinc sulphate | 1 966 | 827 | 1 688 | 771 | 1 624 | 876 |
| Zinc fabricated materials, nes | 841 | 2,142 | 859 | 2,139 | 511 | 1,576 |
| Total | 35 480 | 22,153 | 92 946 | 54,166 | 43 337 | 33,453 |

| | 1981 | | | 1982 | | |
|---|---|---|---|---|---|---|
| | Primary | Secondary | Total | Primary | Secondary | Total |
| | (tonnes) | | | | | |
| **Consumption**[5] | | | | | | |
| Zinc used for, or in the manufacture of: | | | | | | |
| Copper alloys (brass, bronze, etc.) | 9 019 ) | | | 6 141 ) | | |
| Galvanizing: electro | 1 565 ) | 1 336 | 74 966 | 2 078 ) | 219 | 66 571 |
| hot dip | 63 046 ) | | | 58 133 ) | | |
| Zinc die-cast alloy | 12 553 | X | X | 22 041 | X | X |
| Other products (including rolled and ribbon zinc, zinc oxide) | 21 286 | X | X | 7 518 | X | X |
| Total | 107 469 | 5 592 | 113 061 | 95 911 | 4 321 | 100 232 |
| Consumer stocks, year-end | 12 117r | 370 | 12 487r | 5 483 | 376 | 5 859 |

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Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] New refined zinc produced from domestic primary materials (concentrates, slags, residues etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2] Zinc content of ores and concentrates produced. [3] Refined zinc produced from domestic and imported ores. [4] Gross weight. [5] Consumer survey does not represent 100 per cent of Canadian consumption and is therefore consistently less than apparent consumption.

P Preliminary; r Revised; - Nil; .. Not available; nes Not elsewhere specified; X Confidential.

### TABLE 2. CANADA, ZINC MINE OUTPUT, 1982-84

| | 1982 | 1983 | 1984P |
|---|---|---|---|
| | | (tonnes) | (Jan.-Sept.) |
| Newfoundland | 33 157 | 40 905 | 36 981 |
| New Brunswick | 304 619 | 258 731 | 198 507 |
| Quebec | 76 050 | 52 061 | 41 929 |
| Ontario | 286 691 | 317 438 | 252 776 |
| Manitoba-Saskatchewan | 46 390 | 58 816 | 43 415 |
| British Columbia | 88 577 | 83 730 | 77 441 |
| Yukon Territory | 60 210 | - | - |
| Northwest Territories | 293 435 | 258 028 | 256 296 |
| Total | 1 189 129 | 1 069 709 | 907 345 |

P Preliminary.

### TABLE 3. CANADA, ZINC PRODUCTION, EXPORTS AND DOMESTIC SHIPMENTS, 1970, 1975, 1979-84

| | Production | | Exports | | | Producers' Domestic Shipments |
|---|---|---|---|---|---|---|
| | All Forms[1] | Refined[2] | In Ores and Concentrates | Refined | Total | |
| | | | (tonnes) | | | |
| 1970 | 1 135 714 | 417 906 | 809 248 | 318 834 | 1 128 082 | 106 405 |
| 1975 | 1 055 151 | 426 902 | 705 088 | 247 474 | 952 562 | 149 214 |
| 1979 | 1 099 926 | 580 449 | 598 279 | 429 353 | 1 027 632 | 153 744 |
| 1980 | 883 697 | 591 565 | 434 178 | 471 949 | 906 127 | 132 543 |
| 1981 | 911 178 | 618 650 | 516 210 | 453 526 | 969 736 | 131 859 |
| 1982 | 965 607 | 511 870 | 457 751 | 470 390 | 928 141 | 119 714 |
| 1983 | 970 803 | 617 033 | 660 792 | 500 443 | 1 161 235 | 134 424 |
| 1984P | 1 022 054 | 683 000 | | | | 141 600 |

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2] Refined zinc produced from domestic and imported ores.
P Preliminary.

### TABLE 4. CANADA, PRODUCERS' DOMESTIC SHIPMENTS OF REFINED ZINC, 1981-84

| Quarter | 1981 | 1982 | 1983 | 1984P |
|---|---|---|---|---|
| | | (tonnes) | | |
| 1st | 35 044 | 39 767 | 33 717 | 41 405 |
| 2nd | 39 151 | 30 429 | 38 444 | 38 730 |
| 3rd | 27 910 | 21 580 | 29 188 | 30 100 |
| 4th | 29 754 | 27 938 | 33 075 | 31 365 |
| Total | 131 859 | 119 714 | 134 424 | 141 600 |

P Preliminary.

### TABLE 5. WESTERN WORLD PRIMARY ZINC STATISTICS, 1981-84

| | 1981 | 1982 | 1983 | 1984e |
|---|---|---|---|---|
| | | (000 tonnes) | | |
| Mine production (Zn content) | 4 459 | 4 801 | 4 791 | 5 000 |
| Metal production | 4 542 | 4 318 | 4 643 | 4 900 |
| Metal consumption | 4 428 | 4 250 | 4 601 | 4 750 |

Source: International Lead and Zinc Study Group.
e Estimated by Energy, Mines and Resources Canada.

## TABLE 6. CANADA, ZINC-BEARING DEPOSITS CONSIDERED MOST PROMISING FOR FUTURE PRODUCTION

| Company and Province | Deposit Name | Indicated Tonnage (000 tonnes) | Per Cent Zinc | Zinc Content (000 tonnes) |
|---|---|---|---|---|
| **New Brunswick** | | | | |
| Billiton Canada Ltd. and Gowganda Resources Inc. | Restigouche | 2 900 | 6.00 | 174.0 |
| Caribou-Chaleur Bay Mines Ltd. | Caribou | 44 800 | 4.48 | 2 007.0 |
| Cominco Ltd. | Stratmat 61 | 2 040 | 6.29 | 128.3 |
| Key Anacon Mines Limited | Middle Landing | 1 690 | 7.43 | 125.6 |
| Kidd Creek Mines Ltd. and Bay Copper Mines Limited | Halfmile Lake | 10 160 | 7.51 | 763.0 |
| | | 61 590 | 5.19 | 3 197.9 |
| **Quebec** | | | | |
| Les Mines d'Argent Abcourt Inc. and Antiquois Mining Corporation | Barraute | 3 270 | 2.50 | 81.8 |
| Noranda Mines Limited | Magusi | 2 130 | 3.55 | 75.6 |
| Les Mines Selbaie | A-2 Zone | 5 000 | 1.33 | 66.5 |
| | | 10 400 | 2.15 | 223.9 |
| **Ontario** | | | | |
| Corporation Falconbridge Copper | Winston Lake | 2 950 | 17.8 | 525.1 |
| **British Columbia** | | | | |
| Cyprus Anvil Mining Corporation | Cirque | 39 920 | 7.80 | 3 113.8 |
| **Yukon Territory** | | | | |
| Cyprus Anvil Mining Corporation | DY zone | 14 700 | 7.10 | 1 043.7 |
| | Swim Lake | 4 540 | 5.50 | 249.7 |
| Hudson Bay Mining and Smelting Co., Limited | Tom | 7 840 | 8.40 | 658.6 |
| Aberford Resources Ltd. and Ogilvie Joint Venture | Jason | 11 790 | 7.00[e] | 825.3 |
| Placer Development Limited and United States Steel Corporation | Howard's Pass | 272 160[e] | 6.40[e] | 17 418.2 |
| Sulpetro Minerals Limited and Sovereign Metals Corporation | MEL | 4 780 | 5.10 | 243.8 |
| | | 315 760 | 6.51 | 20 439.3 |
| **Northwest Territories** | | | | |
| Cominco Ltd. and Bathurst Norsemines Ltd. | Seven deposits | 19 050 | 4.98 | 948.7 |
| Kidd Creek Mines Ltd. | Izok Lake | 11 020 | 13.77 | 1 517.5 |
| Westmin Resources Limited, Du Pont Canada Inc. and Philipp Brothers (Canada) Ltd. | X-25 | 3 450 | 9.10 | 314.0 |
| | R-190 | 1 270 | 11.90 | 151.1 |
| | | 34 790 | 8.43 | 2 931.3 |
| Canada | | 465 560 | 6.54 | 30 431.3 |

Source: MR 191 Canadian Reserves of Copper, Nickel, Lead, Zinc, Molybdenum, Silver and Gold, as of January 1, 1981; Energy, Mines and Resources Canada, 1981 and company reports.
[e] Estimated.

## TABLE 7. WESTERN WORLD ZINC INDUSTRY, PRODUCTION AND CONSUMPTION, 1983

| | Mine Production | Metal Production | Metal Consumption |
|---|---|---|---|
| | (000 tonnes) | | |
| **Europe** | | | |
| Austria | 19 | 24 | 27 |
| Belgium | - | 263 | 166 |
| Denmark[1] | 73 | - | 9 |
| Finland | 56 | 155 | 26 |
| France | 34 | 249 | 271 |
| Germany F.R. | 114 | 356 | 405 |
| Greece | 21 | - | 13 |
| Ireland | 186 | - | 2 |
| Italy | 43 | 156 | 208 |
| Netherlands | - | 187 | 54 |
| Norway | 32 | 91 | 22 |
| Portugal | - | 4 | 9 |
| Spain | 176 | 198 | 106 |
| Sweden | 205 | - | 34 |
| Switzerland | - | - | 20 |
| United Kingdom | 9 | 88 | 181 |
| Yugoslavia | 73 | 93 | 93 |
| Total | 1 041 | 1 864 | 1 647 |
| **Africa** | | | |
| Algeria | 14 | 31 | 22 |
| Egypt | - | - | 17 |
| Morocco | 8 | - | 4 |
| South Africa[2] | 137 | 82 | 83 |
| Tunisia | 8 | - | 1 |
| Zaire | 75 | 63 | - |
| Zambia | 41 | 38 | 1 |
| Others | - | - | 35 |
| Total | 283 | 214 | 163 |
| **Americas** | | | |
| Argentina | 37 | 34 | 34 |
| Bolivia | 47 | - | - |
| Brazil | 73 | 100 | 102 |
| Canada | 1 070 | 617 | 144 |
| Colombia | - | - | 12 |
| Honduras | 38 | - | - |
| Mexico | 275 | 175 | 89 |
| Peru | 553 | 154 | 16 |
| United States | 293 | 305 | 933 |
| Venezuela | - | - | 15 |
| Others | 6 | - | 24 |
| Total | 2 392 | 1 385 | 1 369 |
| **Asia** | | | |
| Hong Kong | - | - | 30 |
| India | 36 | 54 | 125 |
| Indonesia | - | - | 60 |
| Iran | 25 | - | 16 |
| Japan | 256 | 701 | 771 |
| Korea, Rep. | 57 | 108 | 113 |
| Philippines | 2 | - | 27 |
| Taiwan | - | - | 60 |
| Thailand | 3 | - | 41 |
| Turkey | 31 | 14 | 22 |
| Others | 5 | - | 59 |
| Total | 415 | 877 | 1 324 |
| **Oceania** | | | |
| Australia | 660 | 303 | 79 |
| New Zealand | - | - | 19 |
| Total | 660 | 303 | 98 |
| Total Non-Socialist World | 4 791 | 4 643 | 4 601 |

Source: International Lead and Zinc Study Group.

[1] Includes Greenland. [2] Includes Namibia.
- Nil.

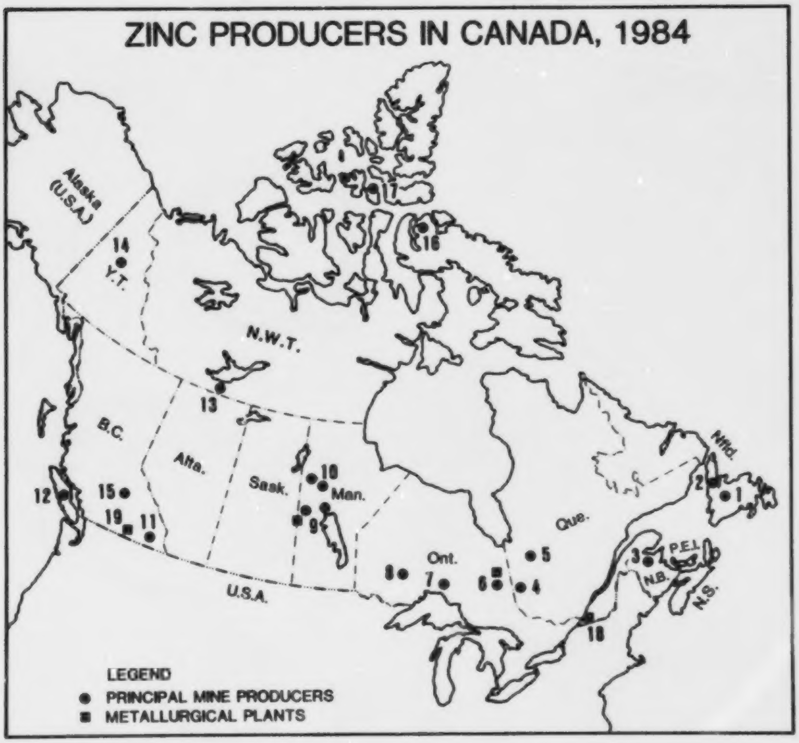
## TABLE 8. CANADA, PRIMARY ZINC METAL CAPACITY, 1984

| Company and Location | Annual Rated Capacity |
|---|---|
| | (tonnes of slab zinc) |
| Canadian Electrolytic Zinc Limited (CEZ)<br>Valleyfield, Quebec | 227 000 |
| Kidd Creek Mines Ltd.<br>Hoyle, Ontario | 127 000 |
| Hudson Bay Mining and Smelting Co., Limited<br>Flin Flon, Manitoba | 73 000 |
| Cominco Ltd.<br>Trail, British Columbia | 272 000 |
| Canada total | 699 000 |

TABLE 9. MONTHLY AVERAGE ZINC PRICES

| | Overseas[1] Producer ($US/tonne) | U.S.[1] Producer (¢US/lb) | Canadian[1] Producer (¢Cdn./lb) | LME[2] Settlement (£/tonne) |
|---|---|---|---|---|
| **1983** | | | | |
| January | $800.0 | 38.6 | 49.0 | 443.7 |
| February | 760.0 | 38.6 | 48.5 | 444.5 |
| March | 750.0 | 37.9 | 46.5 | 455.3 |
| April | 750.0 | 38.0 | 46.8 | 454.0 |
| May | 759.0 | 38.1 | 49.0 | 467.9 |
| June | 780.0 | 39.5 | 49.0 | 464.1 |
| July | 787.6 | 40.0 | 50.4 | 484.4 |
| August | 830.4 | 40.6 | 53.7 | 538.3 |
| September | 880.0 | 43.0 | 56.0 | 559.1 |
| October | 892.9 | 46.1 | 57.0 | 573.8 |
| November | 937.5 | 47.5 | 60.0 | 582.2 |
| December | 958.6 | 48.7 | 60.0 | 597.7 |
| Year Average | 823.8 | 41.4 | 52.2 | 506.2 |
| **1984** | | | | |
| January | 990.9 | 49.2 | 62.9 | 680.4 |
| February | 1 048.1 | 50.6 | 63.5 | 692.6 |
| March | 1 051.8 | 51.1 | 66.0 | 714.8 |
| April | 1 090.0 | 51.9 | 67.0 | 706.6 |
| May | 1 090.0 | 52.8 | 67.0 | 720.6 |
| June | 1 080.5 | 52.5 | 66.6 | 683.7 |
| July | 1 010.5 | 49.5 | 65.5 | 646.7 |
| August | 990.0 | 47.8 | 63.4 | 635.1 |
| September | 957.5 | 46.4 | 61.5 | 611.4 |
| October | 907.0 | 44.2 | 59.3 | 623.3 |
| November | 900.0 | 43.6 | 59.3 | 635.6 |
| December | 900.0 | 43.6 | 59.3 | 669.2 |
| Year Average | 1 001.4 | 48.6 | 63.4 | 668.3 |

Source: Metals Week, ILZSG, Northern Miner.
[1] High grade zinc. [2] G.O.B. zinc.



ZINC PRODUCERS IN CANADA, 1984

Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
1
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3
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5
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9
10
11
12
13
14
15
16
17
18
19
LEGEND
● PRINCIPAL MINE PRODUCERS
■ METALLURGICAL PLANTS

**Principal Producers**
(numbers refer to numbers on map above)

1. ASARCO Incorporated (Buchans Unit)
2. Newfoundland Zinc Mines Limited
3. Brunswick Mining and Smelting Corporation Limited
   Heath Steele Mines Limited
4. Corporation Falconbridge Copper Lake Dufault Division
   Noranda Inc. and Les Mines Gallen Limitée (Gallen Mine)
5. Mattagami Lake Mines Limited
   Noranda Mines Limited (Orchan mine)
6. Kidd Creek Mines Ltd.
7. Noranda Inc. (Geco Division)
8. Mattabi Mines Limited
   Noranda Inc. (Lyon Lake)
9. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake, Osborne Lake, Stall Lake, Ghost Lake, Anderson Lake, Westarm, Flin Flon, White Lake, Centennial, Trout Lake, Spruce Point)
10. Sherritt Gordon Mines Limited (Fox Lake mine and Ruttan mine)
11. Cominco Ltd. (Sullivan mine)
    Teck Corporation (Beaverdell mine)
    Dickenson Mines Limited (Silmonac mine)
12. Westmin Resources Limited
13. Pine Point Mines Limited
14. United Keno Hill Mines Limited
15. Northair Mines Ltd.
16. Nanisivik Mines Ltd.
17. Cominco Ltd. (Polaris mine)

**Metallurgical Plants**

6. Kidd Creek Mines Ltd., Hoyle
9. Hudson Bay Mining and Smelting Co., Limited, Flin Flon
18. Canadian Electrolytic Zinc Limited, Valleyfield
19. Cominco Ltd., Trail

PRINCIPAL CANADIAN NONFERROUS AND PRECIOUS METAL PRODUCERS IN 1983, WITH HIGHLIGHTS FOR 1984

| Company and Mine Location | Capacity | Grades of Ore Mined |  |  |  |  |  | Ore Milled | Metal Contained in Concentrates Produced |  |  |  |  |  | Highlights |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Cu | Ni | Pb | Zn | Ag | Au |  | Copper | Nickel | Zinc | Lead | Gold | Silver |  |
|  | (tonnes per day) | (per cent) |  |  |  | (g/tonne) |  | (tonnes) | (tonnes) |  |  |  | (kilograms) |  |  |
| **NEWFOUNDLAND** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| ASARCO Incorporated<br>Buchans | 1 089 | 0.79 | - | 4.79 | - | 62.40 | 0.55 | 38 102 | 96 | - | 1 953 | 1 315 | 12 | 1 705 | Mine closed permanently, September 1984. |
| Newfoundland Zinc Mines Limited<br>Daniel's Harbour | 1 497 | - | - | - | 8.10 | - | - | 486 646 | - | - | 38 947 | - | - | - |  |
| **NEW BRUNSWICK** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Anaconda Canada Exploration Ltd.<br>Caribou property<br>Restigouche | - | - | - | - | - | 48.00 | 5.14 | 60 346 | - | - | - | - | 104 | 2 036 | Heap leach operation. |
| Brunswick Mining and Smelting Corporation Limited, Nos. 6 and 12 mines<br>Bathurst | 10 500 | 0.30 | - | 3.51 | 8.08 | 98.16 | - | 3 438 859 | 4 795 | - | 265 690 | 80 473 | - | 233 701 | Ore extraction at No. 6 mine completed in 1983. |
| Heath Steele Mines Limited<br>Newcastle | 3 629 | 0.97 | - | 1.50 | 3.71 | 58.63 | 0.69 | 449 615 | 2 752 | - | 12 637 | 3 097 | 77 | 18 121 | Underground production suspended May 1983. |
| **QUEBEC** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Agnico-Eagle Mines Limited<br>Joutel | 998 | - | - | - | - | 0.86 | 5.97 | 291 528 | - | - | - | - | 1 536 | 208 |  |
| Bachelor Lake Gold Mines Inc.<br>Desmaraisville | 454 | - | - | - | - | 0.69 | 5.69 | 151 404 | - | - | - | - | 798 | 88 |  |
| Belmoral Mines Ltd.<br>Ferderber and Dumont mines<br>Val d'Or | 816 | - | - | - | - | 0.72 | 6.27 | 219 866 | - | - | - | - | 1 299 | 140 |  |
| Camflo Mines Limited<br>Malartic | 1 134 | - | - | - | - | 0.34 | 5.73 | 423 101 | - | - | - | - | 2 405 | 110 |  |

TABLE (cont'd)

| Company and Mine Location | Capacity | Grades of Ore Mined | | | | | | Ore Milled | Metal Contained in Concentrates Produced | | | | | | Highlights |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cu | Ni | Pb | Zn | Ag | Au | | Copper | Nickel | Zinc | Lead | Gold | Silver | |
| | (tonnes per day) | (per cent) | | | | (g/tonne) | | (tonnes) | (tonnes) | | | | (kilograms) | | |
| QUEBEC (cont'd) | | | | | | | | | | | | | | | |
| Campbell Resources Inc.<br>Chibougamau | 3 402 | 0.78 | - | - | - | 6.45 | 2.92 | 273 561 | 2 015 | - | - | - | 729 | 976 | |
| Corporation Falconbridge Copper<br>Lake Dufault Division<br>Millenbach and Corbet mines<br>Noranda | 1 651 | 3.32 | - | - | 1.19 | 18.36 | 0.93 | 379 118 | 12 213 | - | 3 141 | - | 278 | 4 682 | Production resumed April 1983 after a seven-month shutdown. |
| Opemiska Division<br>Perry, Springer & Cooke mines<br>Chapais | 2 585 | 1.44 | - | - | - | 9.96 | 1.65 | 922 654 | 12 876 | - | - | - | 1 576 | 7 324 | |
| Gaspé Copper Mines Limited<br>Copper Mountain and Needle Mountain mines<br>Murdochville | | | | | | | | | | | | | | | Both mines remained shut through 1983. Needle Mountain (underground) reopened at a reduced level in September 1984. Copper Mountain remained shut through 1984. |
| Mascocho Explorations Limited<br>Montauban mine | 227 | - | - | - | - | 13.61 | 4.39 | 57 024 | - | - | - | - | 196 | 250 | |
| Noranda Inc.<br>Horne Division | 3 447 | 3.13 | - | - | - | 0.88 | 1.56 | 630 560 | 18 560 | - | - | - | 840 | 297 | Smelter slag milled and then remelted. |
| Mattagami Division | 4 082 | 0.90 | - | 0.04 | 4.85 | 17.55 | 0.41 | 1 106 031 | 8 208 | - | 48 443 | - | 193 | 10 102 | |
| Northgate Patino Mines Inc.<br>Copper Rand and Portage mines | 2 903 | 1.65 | - | - | - | 9.67 | 3.22 | 681 089 | 10 348 | - | - | - | 1 071 | 4 176 | |
| Lemoine mine<br>Chibougamau | 327 | 2.30 | - | - | 4.35 | 44.57 | 2.57 | 19 061 | 418 | - | 640 | - | 43 | 740 | Closed, March 1983. |
| Selco Division - BP Resources Canada Ltd.<br>Joutel | 1 497 | 3.43 | - | - | 0.59 | 37.20 | 1.71 | 535 300 | 17 477 | - | - | - | 792 | 16 552 | |
| Sigma Mines (Quebec) Limited<br>Val d'Or | 1 270 | - | - | - | - | 0.86 | 4.56 | 436 103 | - | - | - | - | 1 914 | 540 | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Société Minière Louvem Inc. (Soquem) | 564 | - | - | - | - | 1.71 | 4.01 | 151 250 | - | - | - | - | 532 | 202 | |
| Lac Minerals Ltd.<br>Doyon Division | 1 089 | - | - | - | - | 0.41 | 5.28 | 413 580 | - | - | - | - | 1 981 | 150 | |
| East-Malartic Division | 1 633 | - | - | - | - | 0.37 | 4.97 | 617 091 | - | - | - | - | 2 833 | 209 | |
| Terrains Aurifères Division | 1 814 | - | - | - | - | 1.54 | 6.21 | 549 392 | - | - | - | - | 3 200 | 718 | |
| Teck Corporation<br>Lamaque Division<br>Val d'Or | 1 905 | - | - | - | - | 1.12 | 6.06 | 445 782 | - | - | - | - | 2 548 | 489 | |
| **ONTARIO** | | | | | | | | | | | | | | | |
| Agnico-Eagle Mines Limited Silver Division<br>Cobalt | 363 | - | - | - | - | 672.69 | - | 38 111 | - | - | - | - | - | 24 171 | |
| Campbell Red Lake Mines Limited<br>Red Lake | 975 | - | - | - | - | 2.06 | 20.50 | 353 330 | - | - | - | - | 6 818 | 688 | |
| Campbell Red Lake Mines Limited<br>Detour Joint Venture<br>James Bay | 2 500 | - | - | - | - | 0.38 | 2.37 | 265 693 | - | - | - | - | 536 | 85 | |
| Consolidated Louvanne Gold Mines Limited<br>Nakina | 181 | - | - | - | - | 3.09 | 7.44 | 18 606 | - | - | - | - | 127 | 47 | |
| Cullaton Lake Gold Mines Limited<br>Sudbury | 654 | - | - | - | - | 1.99 | 5.01 | 166 423 | - | - | - | - | 766 | 233 | |
| Dome Mines Limited<br>South Porcupine | 1 996 | - | - | - | - | 0.93 | 4.73 | 691 638 | - | - | - | - | 4 293 | 600 | |
| Dickenson-Sullivan Joint Venture<br>Red Lake | 635 | - | - | - | - | 1.03 | 10.49 | 186 670 | - | - | - | - | 1 613 | 154 | |
| Falconbridge Limited (6 mines)<br>Sudbury district | 10 342 | 1.13 | 1.28 | - | - | 6.86 | 0.14 | 2 660 351 | 28 555 | 28 224 | - | - | 189 | 9 424 | Falconbridge mine closed permanently after rockburst in June.<br>Operations resumed Jan. 1983 after a 6-month shutdown. |
| Goldlund Mines Limited<br>Sioux Lookout | 318 | - | - | - | - | - | 5.73 | 56 406 | - | - | - | - | 248 | - | |

TABLE (cont'd)

| Company and Mine Location | Capacity | Grades of Ore Mined |  |  |  |  |  | Ore Milled | Metal Contained in Concentrates Produced |  |  |  |  |  | Highlights |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Cu | Ni | Pb | Zn | Ag | Au |  | Copper | Nickel | Zinc | Lead | Gold | Silver |  |
|  | (tonnes per day) | (per cent) |  |  |  | (g/tonne) |  | (tonnes) | (tonnes) |  |  |  | (kilograms) |  |  |
| **ONTARIO** (cont'd) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Inco Limited<br>10 mines, Sudbury area and Shebandowan | 49 442 | 1.29 | 1.30 | - | - | 5.14 | 0.17 | 6 352 956 | 63 942 | 63 731 | - | - | 665 | 25 486 | Copper Cliff North mine opened in January.<br>Operations reopened April 1985 after a 10-month shutdown. |
| Kerr Addison Mines Limited<br>Virginiatown | 1 225 | - | - | - | - | 0.38 | 4.90 | 362 575 | - | - | - | - | 1 735 | 117 |  |
| Lac Minerals Ltd.<br>Macassa Division<br>Kirkland Lake | 586 | - | - | - | - | 2.37 | 17.11 | 124 164 | - | - | - | - | 2 043 | 250 |  |
| Kidd Creek Mines Ltd.<br>Limited<br>Timmins | 13 500 | 2.57 | - | 0.25 | 5.90 | 81.22 | 0.06 | 4 215 441 | 100 008 | - | 204 657 | 3 461 | - | 277 196 | Expansion of zinc plant continuing; expansion of copper smelter and refinery to 90 000 tpy Cu scheduled for completion in 1988. |
| Mattabi Mines Limited<br>Lyon Lake mine<br>"F" Group mine<br>Sturgeon Lake | 2 722 | 0.90 | - | 0.94 | 8.55 | 127.89 | 0.41 | 934 451 | 5 467 | - | 72 532 | 4 438 | 249 | 100 085 |  |
| Noranda Inc.<br>Geco Division<br>Manitouwadge | 3 856 | 1.60 | - | 0.11 | 3.40 | 46.63 | 0.10 | 1 246 993 | 18 318 | - | 37 022 | 494 | 88 | 46 144 |  |
| Pamour Porcupine Mines Limited<br>Pamour Division<br>Timmins | 2 585 | - | - | - | - | 0.71 | 3.09 | 751 331 | - | - | - | - | 2 055 | 373 |  |
| Pamour Porcupine Mines, Limited<br>Schumacher Division<br>Timmins | 2 722 | 0.04 | - | - | - | 5.62 | 3.58 | 641 910 | 131 | - | - | - | 1 863 | 1 903 |  |
| Sulpetro Minerals Limited | 454 | - | - | - | - | 105.94 | - | 35 393 | - | - | - | - | - | 2 521 |  |
| Teck Corporation<br>Silverfields Division<br>Cobalt | 222 | 0.60 | 0.25 | - | - | 257.14 | - | 18 144 | - | - | - | - | - | 4 385 |  |
| **MANITOBA** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Brinco Limited<br>San Antonio mine<br>Bissett | 408 | - | - | - | - | 0.89 | - | 28 263 | - | - | - | - | 129 | 22 |  |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| udson Bay Mining and<br>melting Co. Limited<br>9 mines),<br>Flin Flon concentrators<br>& Snow Lake concentrators | 10 523 | 2.20 | - | 0.10 | 2.86 | 16.32 | 1.43 | 1 918 688 | 38 566 | - | 41 442 | 705 | 1 618 | 22 026 | |
| nco Limited<br>Thompson and Pipe mines<br>Thompson district | 12 701 | 0.14 | 1.90 | - | - | 5.14 | 0.10 | 1 874 537 | 1 292 | 30 530 | - | - | 117 | 7 520 | The Pipe open-pit mine closed, but stockpiled ore sufficient to last through 1985. Production from Thompson open-pit expected in early 1986. |
| erritt Gordon Mines<br>mited<br>ox mine<br>Lynn Lake district | 2 722 | 2.10 | - | - | 1.94 | 14.06 | 0.48 | 554 122 | 10 801 | - | 7 596 | - | 210 | 6 140 | |
| uttan mine<br>Leaf Rapids | 6 804 | 1.62 | - | - | 0.73 | 8.57 | 0.34 | 1 295 570 | 19 819 | - | 6 601 | - | 311 | 8 412 | |
| TISH COLUMBIA | | | | | | | | | | | | | | | |
| ton Operating<br>rporation<br>Afton mine<br>Kamloops | 7 711 | 0.53 | - | - | - | 2.09 | 0.31 | 1 075 853 | 4 626 | - | - | - | 261 | 1 330 | |
| enda Mines Ltd.<br>Peachland | 27 216 | 0.14 | - | - | - | 1.20 | 0.02 | 8 185 403 | 9 927 | - | - | - | 100 | 5 776 | Closed Sept. 30/83 to May 28/84. October 1984 announcement that mine would close Dec. 14/84. |
| thlehem Copper<br>rporation<br>ono and Jersey mines<br>Highland Valley | 17 690 | 0.38 | - | - | - | 2.40 | 0.03 | 3 112 829 | | | | | | | |
| minco Ltd.<br>pper Division<br>Valley Copper<br>mine | 19 051 | 0.52 | - | - | - | 4.63 | 0.03 | 7 171 985 | 33 336 | - | - | - | 108 | 13 240 | |
| minco Ltd.<br>ullivan mine<br>Kimberley | 10 886 | - | - | 4.39 | 3.50 | 51.09 | - | 2 017 383 | - | - | 60 846 | 79 330 | - | 97 123 | Mechanization continuing. |
| arolin Mines Ltd.<br>Hope | 1 361 | - | - | - | - | 0.10 | 2.71 | 359 017 | - | - | - | - | 552 | 7 | |
| ickenson Mines Ltd.<br>Silvana Division<br>Silmonac mine<br>New Denver | 109 | - | - | 3.02 | 3.23 | 311.31 | - | 28 234 | - | - | 560 | 749 | - | 7 795 | |
| nkow Mines Ltd.<br>Keremeos | 408 | 0.42 | - | 0.05 | 0.13 | 182.40 | 5.62 | 5 583 | - | - | - | - | 27 | 956 | |

TABLE (cont'd)

| Company and Mine | | Grades of Ore Mined | | | | | | Ore | Metal Contained in Concentrates Produced | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location | Capacity | Cu | Ni | Pb | Zn | Ag | Au | Milled | Copper | Nickel | Zinc | Lead | Gold | Silver | Highlights |
| | (tonnes per day) | (per cent) | | | | (g/tonne) | | (tonnes) | | | (tonnes) | | (kilograms) | | |
| **BRITISH COLUMBIA** (cont'd) | | | | | | | | | | | | | | | |
| Du Pont of Canada Inc.<br>Exploration Limited<br>Baker Mine | 91 | - | - | - | - | 290.06 | 14.06 | 29 022 | - | - | - | - | 374 | 7 048 | |
| Erickson Gold Mining Limited<br>Cassiar | 181 | - | - | - | - | 15.09 | 17.49 | 63 367 | - | - | - | - | 1 061 | 838 | |
| Esso Resources Canada Limited<br>Esso Minerals Canada Division<br>Granduc mine | 3 629 | 1.48 | - | - | - | 11.31 | 0.20 | 1 031 805 | 14 976 | - | - | - | 161 | 9 606 | Closed April 6, 1984. |
| Falconbridge Limited<br>Wesfrob Mining Division<br>Tasu mine<br>Tasu | 5 443 | 0.29 | - | - | - | 2.98 | 0.07 | 906 563 | 2 262 | - | - | - | 46 | 2 034 | Closed October 1983. |
| Gibraltar Mines Limited<br>McLeese Lake<br>Caribou district | 37 195 | 0.27 | - | - | - | 0.69 | - | 13 437 210 | 27 905 | - | - | - | - | 3 630 | |
| Highmont Operating Corporation (Teck Corp.)<br>Highland Valley | 22 680 | 0.21 | - | - | - | - | - | 9 799 692 | 16 027 | - | - | - | - | - | On standby October 19, 1984 due to low metal prices. |
| Lornex Mining Corporation Ltd.<br>Lornex mine<br>Highland Valley | 72 575 | 0.34 | - | - | - | 2.56 | - | 28 766 769 | 85 196 | - | - | - | - | 22 383 | |
| The Mosquito Creek Gold Mining Company Limited<br>Cariboo | 91 | - | - | - | - | 4.29 | 14.06 | 17 188 | - | - | - | - | 206 | 62 | |
| Noranda Inc.<br>Bell Copper mine<br>Granisle mine<br>Babine Lake | | | | | | | | | | | | | | | Closed through 1983 and 1984. |
| Noranda Inc.<br>Goldstream Division | 1 361 | 3.14 | - | - | 1.70 | 17.14 | - | 293 928 | 8 203 | - | 187 | - | - | 2 642 | Production suspended April 1984. |
| Newmont Mines Limited<br>Similkameen Division<br>Princeton | 19 958 | 0.36 | - | - | - | 1.23 | 0.32 | 6 809 286 | 21 570 | - | - | - | 507 | 4 907 | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Placer Development Limited/Equity Silver mines | 29 937 | 0.48 | - | - | | 91.99 | 1.30 | 2 180 000 | 8 080 | - | - | - | 880 | 154 206 | |
| Scottie Gold Mines Ltd.<br>Summit Lake | 181 | - | - | - | - | 6.86 | 10.79 | 61 158 | - | - | - | - | 1 060 | 352 | |
| Taurus Resources Ltd.<br>Cassiar | 113 | - | - | - | - | 3.70 | 5.01 | 42 256 | - | - | - | - | 174 | 87 | |
| Teck Corporation<br>Beaverdell mine<br>Beaverdell | 109 | - | - | 0.28 | 0.51 | 259.66 | - | 32 946 | - | - | 81 | 63 | - | 9 540 | |
| Utah Mines Ltd.<br>Island Copper mine<br>Coal Harbour | 38 102 | 0.44 | - | - | - | 1.37 | 0.21 | 16 330 081 | 60 026 | - | - | - | 1 715 | 14 718 | |
| Westmin Resources Limited<br>Lynx and Myra mines<br>Buttle Lake | 907 | 1.10 | - | 1.08 | 7.45 | 121.03 | 2.57 | 215 718 | 2 175 | - | 15 462 | 2 081 | 580 | 27 110 | Development to bring H-W orebody into production in 1985 continuing. |
| **YUKON TERRITORY** | | | | | | | | | | | | | | | |
| Cyprus Anvil Mining Corporation<br>Faro | | | | | | | | | | | | | | | Production suspended June 1982. Waste-stripping program in progress. |
| United Keno Hill Mines Limited<br>Elsa, Husky, No Cash, Keno mines<br>Elsa | 450 | - | - | 0.65 | 3.70 | - | 778.29 | 50 341 | - | - | 124 | 953 | - | 56 958 | |
| **NORTHWEST TERRITORIES** | | | | | | | | | | | | | | | |
| Cominco Ltd.<br>Con and Rycon mines<br>Yellowknife | 658 | - | - | - | - | 3.43 | 12.45 | 191 721 | - | - | - | - | 2 193 | 604 | |
| Pine Point mine<br>Pine Point | 9 979 | - | - | 2.68 | 8.16 | - | - | 893 577 | - | - | 67 106 | 21 424 | - | - | |
| Polaris mine<br>Little Cornwallis Island | 2 041 | - | - | 5.17 | 16.81 | - | - | 827 582 | - | - | 131 866 | 38 975 | - | - | New mine, production started early 1982, production suspended for 1 month commencing mid-December 1984. |
| Cullaton Lake Gold Mines Ltd.<br>Cullaton Lake | 299 | - | - | - | - | 0.69 | 12.72 | 98 553 | - | - | - | - | 1 196 | 62 | |

TABLE (cont'd)

| Company and Mine Location | Capacity (tonnes per day) | Grades of Ore Mined |  |  |  |  |  | Ore Milled (tonnes) | Metal Contained in Concentrates Produced |  |  |  |  |  | Highlights |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Cu | Ni | Pb | Zn | Ag | Au |  | Copper | Nickel | Zinc | Lead | Gold | Silver |  |
|  |  | (per cent) |  |  |  | (g/tonne) |  |  | (tonnes) |  |  |  | (kilograms) |  |  |
| **NORTHWEST TERRITORIES** (cont'd) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Echo Bay Mines Ltd.<br>Lupin mine<br>Contwoyto Lake | 1 036 | - | - | - | - | 1.20 | 12.03 | 323 036 | - | - | - | - | 3 666 | 366 |  |
| Giant Yellowknife Mines Limited<br>Giant mine<br>Yellowknife | 1 134 | - | - | - | - | 2.33 | 7.70 | 296 989 | - | - | - | - | 1 963 | 658 |  |
| Salmita mine | 165 | - | - | - | - | 3.43 | 15.63 | 11 926 | - | - | - | - | 159 | 35 |  |
| Nanisivik Mines Ltd.<br>Nanisivik | 1 996 | - | - | 1.08 | 10.18 | 58.70 | - | 619 300 | - | - | 61 042 | 6 167 | - | 26 299 |  |
| Terra Mines Ltd.<br>Smallwood and Norex mines<br>Camsell River | 363 | 0.19 | - | 0.34 | 0.36 | 661.71 | - | 72.316 | - | - | - | - | - | 48 610 |  |

# Statistical Report

The statistical material contained in this summary was principally derived from surveys conducted by the Information Systems Division of the Mineral Policy Sector, Energy, Mines and Resources Canada.

The statistical survey program of Energy, Mines and Resources Canada is conducted jointly with the provincial governments and Statistics Canada. This joint program is intended to minimize the reporting burden on the mineral companies. The cooperation of the companies that provide information is greatly appreciated. Without this cooperation, a statistical report of this nature would not be possible. International mineral statistics contained in this summary are derived from the U.S. Bureau of Mines, The American Bureau of Metal Statistics, The World Bureau of Metal Statistics, **Metals Week**, **Engineering and Mining Journal**, The United Nations and the Organization for Economic Co-operation and Development (OECD).

This statistical summary of the mineral industry in Canada for the year 1983-84 was prepared by J.T. Brennan and staff, Statistics Section, Mineral Policy Sector, Energy, Mines and Resources Canada, Ottawa. Telephone (613) 995-9466.

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CANADA, GENERAL ECONOMIC

| | | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|---|
| Gross national product, current dollars | $ million | 79,815 | 85,685 | 94,450 | 105,234 | 123,560 |
| Gross national product, constant dollars (1971 = 100) | " | 86,225 | 88,390 | 94,450 | 100,248 | 107,812 |
| Value of manufacturing industry shipments | " | 45,930 | 46,381 | 50,276 | 56,191 | 66,674 |
| Value of mineral production | " | 4,734 | 5,722 | 5,963 | 6,408 | 8,370 |
| Merchandise exports | " | 14,498 | 16,401 | 17,397 | 19,671 | 24,838 |
| Merchandise imports | " | 14,130 | 13,952 | 15,618 | 18,669 | 23,325 |
| Balance of payments, current account | " | -917 | +1,106 | +431 | -386 | +108 |
| Corporation profits before taxes | " | 8,294 | 7,699 | 8,681 | 10,799 | 15,417 |
| Capital investment current dollars[r] | " | 17,232 | 18,015 | 20,800 | 23,051 | 27,848 |
| Capital investment, constant dollars[r] (1971 = 100) | " | 18,850 | 18,904 | 20,800 | 21,955 | 24,384 |
| Population | 000's | 21,001 | 21,297 | 21,568 | 21,802 | 22,043 |
| Labour force | " | 8,194 | 8,395 | 8,639 | 8,897 | 9,276 |
| Employed | " | 7,832 | 7,919 | 8,104 | 8,344 | 8,761 |
| Unemployed | " | 362 | 476 | 535 | 553 | 515 |
| Unemployment rate | per cent | 4.4 | 5.7 | 6.2 | 6.2 | 5.5 |
| Labour income | $ million | 43,065 | 46,706 | 51,528 | 57,570 | 135.9 |
| Index industrial production | 1971=100 | 93.6 | 94.9 | 100.0 | 107.6 | 119.0 |
| Index manufacturing production | " | 95.8 | 94.5 | 100.0 | 107.7 | 119.1 |
| Index mining production | " | 86.9 | 98.7 | 100.0 | 104.4 | 117.8 |
| Index gross domestic product | 1971=100 | 92.2 | 94.4 | 100.0 | 105.2 | 114.1 |
| Consumer price index | 1981=100 | 39.7 | 41.0 | 42.2 | 44.2 | 47.6 |

P Preliminary; [r] Revised.

INDICATORS, 1969-83

| 1974 | 1975 | 1976r | 1977r | 1978r | 1979r | 1980r | 1981r | 1982 | 1983p |
|---|---|---|---|---|---|---|---|---|---|
| 147,528 | 165,343 | 191,857 | 210,189 | 232,211 | 264,279 | 297,556 | 339,797 | 358,302 | 209,340 |
| 111,678 | 113,005 | 119,612 | 121,988 | 126,347 | 130,362 | 131,765 | 136,108 | 130,065 | 134,353 |
| 82,455 | 88,427 | 98,076 | 109,747 | 129,019 | 152,133 | 165,985 | 188,212 | 183,432 | 199,560 |
| 11,754 | 13,[illegible]7 | 15,693 | 18,473 | 20,319 | 26,135 | 31,926 | 32,420 | 33,837 | 35,976 |
| 31,739 | 32,[illegible] | 37,651 | 43,685 | 52,259 | 64,317 | 74,446 | 81,203 | 84,540 | 90,825 |
| 31,722 | 34,7[illegible] | 37,494 | 42,363 | 50,108 | 62,871 | 69,274 | 79,129 | 66,726 | 73,120 |
| -1,460 | -4,75[illegible] | -3,842 | -4,301 | -4,935 | -4,962 | -1,096 | -5,346 | 2,665 | 1,686 |
| 20,062 | 19,663 | 19,985 | 21,090 | 25,360 | 34,884 | 36,456 | 32,638 | 21,110 | 32,684 |
| 34,260 | 40,044 | 44,927 | 48,376 | 52,482 | 60,921 | 69,196 | 82,058 | 79,330 | 77,647 |
| 25,694 | 26,661 | 27,731 | 27,606 | 27,585 | 29,448 | 30,461 | 32,401 | 29,265 | 27,844 |
| 22,364 | 22,697 | 22,993 | 23,258 | 23,476 | 23,671 | 23,936 | 24,342 | 24,634 | 24,890 |
| 9,639 | 9,974 | 10,203 | 10,500 | 10,895 | 11,231 | 11,573 | 11,904 | 11,958 | 12,183 |
| 9,125 | 9,284 | 9,477 | 9,651 | 9,987 | 10,395 | 10,708 | 11,006 | 10,644 | 10,734 |
| 514 | 690 | 726 | 849 | 908 | 836 | 865 | 898 | 1,314 | 1,448 |
| 5.3 | 6.9 | 7.1 | 8.1 | 8.3 | 7.4 | 7.5 | 7.5 | 11.0 | 11.9 |
| 79,846 | 93,299 | 109,053 | 120,508 | 131,702 | 148,256 | 167,936 | 193,874 | 208,180 | 219,793 |
| 122.8 | 115.5 | 122.6 | 125.7 | 129.9 | 137.9 | 135.9 | 136.5 | 123.0 | 129.7 |
| 123.4 | 116.2 | 123.1 | 125.5 | 131.9 | 138.1 | 133.7 | 137.8 | 121.3 | 128.6 |
| 114.0 | 100.9 | 103.1 | 106.1 | 97.8 | 107.1 | 109.6 | 104.6 | 92.7 | 96.2 |
| 119.3 | 120.4 | 126.4 | 130.1 | 134.4 | 139.3 | 139.8 | 145.5 | 139.2 | 142.9 |
| 52.8 | 58.5 | 62.9 | 67.9 | 73.9 | 80.7 | 88.9 | 100.0 | 110.8 | 117.2 |

TABLE 1. MINERAL PRODUCTION[1] OF CANADA, 1982 AND 1983, AND AVERAGE 1979-83

| | Unit of Measure | 1982 | | 1983P | | Average 1979-83 | |
|---|---|---|---|---|---|---|---|
| | | (Quantity) | ($000) | (Quantity) | ($000) | (Quantity) | ($000) |
| **Metals** | | | | | | | |
| Antimony | t | .. | 2,455 | .. | 2,350 | 1 477 | 4,667 |
| Bismuth | t | 189 | 1,057 | 202 | 1,031 | 169 | 1,040 |
| Cadmium | t | 836 | 2,684 | 1 107 | 3,388 | 1 014 | 5,276 |
| Cobalt | t | 1 274 | 38,741 | 1 584 | 53,760 | 1 739 | 88,995 |
| Columbium ($Cb_2O_5$) | t | 3 086 | 20,832 | 1 600 | 11,200 | 2 480 | 16,248 |
| Copper | 000 t | 612 | 1,195,083 | 625 | 1,307,307 | 656 | 1,480,600 |
| Gold | kg | 64 735 | 968,012 | 70 746 | 1,186,411 | 57 856 | 966,655 |
| Iron ore | 000 t | 33 198 | 1,201,256 | 32 382 | 1,143,380 | 44 763 | 1,520,212 |
| Iron remelt | 000 t | .. | 103,614 | .. | 94,000 | 407 | 98,159 |
| Lead | 000 t | 272 | 197,335 | 259 | 152,883 | 272 | 259,618 |
| Molybdenum | t | 13 961 | 159,142 | 10 523 | 103,651 | 12 080 | 236,523 |
| Nickel | 000 t | 89 | 600,936 | 122 | 766,351 | 136 | 986,294 |
| Platinum group | kg | 7 105 | 82,253 | 5 195 | 67,885 | 8 627 | 100,349 |
| Selenium | t | 222 | 2,294 | 190 | 1,916 | 233 | 5,712 |
| Silver | t | 1 134 | 415,204 | 1 106 | 500,441 | 1 153 | 536,197 |
| Tantalum ($Ta_2O_5$) | t | 59 | 7,243 | - | - | 87 | 13,348 |
| Tellurium | t | 18 | 577 | 12 | 319 | 24 | 982 |
| Tin | t | 135 | 1,915 | 141 | 2,519 | 219 | 3,771 |
| Tungsten ($WO_3$) | t | 3 030 | .. | 1 538 | .. | 2 868 | .. |
| Uranium (U) | t | 7 643 | 837,468 | 7 035 | 722,727 | 7 032 | 734,523 |
| Zinc | 000 t | 966 | 1,036,096 | 971 | 1,116,423 | 966 | 1,032,080 |
| Total metals | | | 6,874,197 | | 7,237,942 | | 8,091,250 |
| **Nonmetals** | | | | | | | |
| Asbestos | 000 t | 834 | 364,795 | 829 | 402,280 | 1 120 | 508,287 |
| Barite | 000 t | .. | 2,966 | .. | 2,970 | 59 | 3,617 |
| Gemstone | t | .. | 405 | .. | 363 | 241 | 785 |
| Gypsum | 000 t | 5 987 | 46,608 | 7 481 | 56,790 | 7 186 | 46,183 |
| Magnesitic dolomite and brucite | 000 t | .. | 8,216 | .. | 8,108 | 53 | 9,438 |
| Nepheline syenite | 000 t | 550 | 17,324 | 528 | 15,590 | 574 | 16,160 |
| Peat | 000 t | 487 | 54,261 | 544 | 52,503 | 488 | 48,808 |
| Potash ($K_2O$) | 000 t | 5 309 | 630,562 | 6 203 | 620,912 | 6 472 | 799,819 |
| Pyrite, pyrrhotite | 000 t | 20 | 220 | - | - | 9 | 190 |
| Quartz | 000 t | 1 784 | 32,424 | 1 988 | 38,793 | 2 126 | 32,335 |
| Salt | 000 t | 7 940 | 156,620 | 8 590 | 174,261 | 7 825 | 139,620 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Soapstone, talc & pyrophyllite | 000 t | 71 | 5,511 | 97 | 7,785 | 87 | 5,014 |
| Sodium sulphate | 000 t | 547 | 47,462 | 447 | 43,363 | 491 | 37,182 |
| Sulphur in smelter gas | 000 t | 627 | 42,027 | 803 | 50,691 | 755 | 36,708 |
| Sulphur, elemental | 000 t | 6 945 | 569,928 | 6 327 | 428,119 | 7 053 | 450,004 |
| Total nonmetals | 000 t | | 1,979,329 | | 1,902,528 | | 2,134,150 |
| **Fuels** | | | | | | | |
| Coal | 000 t | 42 811 | 1,294,476 | 44 250 | 1,300,000 | 39 407 | 1,091,795 |
| Natural gas | 000 $m^3$ | 75 977 000 | 7,262,446 | 69 266 000 | 6,623,158 | 80 120 000 | 6,262,181 |
| Natural gas by-products | 000 $m^3$ | 18 466 | 2,302,000 | 17 408 | 2,568,635 | 18 714 | 2,058,635 |
| Petroleum, crude | 000 $m^3$ | 73 790 | 12,179,454 | 76 874 | 14,470,793 | 79 121 | 10,518,823 |
| Total fuels | | | 23,038,376 | | 24,962,586 | | 19,931,434 |
| **Structural materials** | | | | | | | |
| Clay products | 000 $ | .. | 95,993 | .. | 127,357 | .. | 114,489 |
| Cement | 000 t | 8 426 | 673,653 | 7 828 | 650,833 | 9 688 | 645,134 |
| Lime | 000 t | 2 197 | 142,081 | 2 126 | 139,638 | 2 258 | 129,520 |
| Sand and gravel | 000 t | 216 274 | 554,608 | 199 293 | 514,609 | 247 380 | 510,341 |
| Stone | 000 t | 59 181 | 263,249 | 62 359 | 269,394 | 84 297 | 305,111 |
| Total structural materials | | | 1,729,584 | | 1,701,831 | | 1,704,595 |
| **Other minerals**[2] | | .. | 215,536 | .. | 171,590 | .. | 169,925 |
| Total, all minerals | | | 33,837,022 | | 35,976,477 | | 32,031,354 |

Notes: [1] Production statistics for the following are not available for publication: helium, nitrogen and yttrium.
[2] Other minerals include arseneous trioxide, bentonite, calcium, cesium, diatomite, graphite, ilmenite, indium, magnesium, mica, pumice, rhenium, rhubidium, serpentine, strontium, titanium dioxide for which the value of production is confidential.
P Preliminary; .. Not available; - Nil.

TABLE 2. CANADA, VALUE OF MINERAL PRODUCTION, PER CAPITA VALUE OF MINERAL PRODUCTION, AND POPULATION, 1954-83

| | Metallics | Industrial Minerals | Fuels | Other Minerals[1] | Total | Per Capita Value of Mineral Production | Population of Canada |
|---|---|---|---|---|---|---|---|
| | | ($ million) | | | | ($) | (000) |
| 1954 | 802 | 333 | 353 | | 1,488 | 97.36 | 15,287 |
| 1955 | 1,008 | 373 | 414 | | 1,795 | 114.37 | 15,698 |
| 1956 | 1,146 | 420 | 519 | | 2,085 | 129.65 | 16,081 |
| 1957 | 1,159 | 466 | 565 | | 2,190 | 131.87 | 16,610 |
| 1958 | 1,130 | 460 | 511 | | 2,101 | 122.99 | 17,080 |
| 1959 | 1,371 | 503 | 535 | | 2,409 | 137.79 | 17,483 |
| 1960 | 1,407 | 520 | 566 | | 2,493 | 139.48 | 17,870 |
| 1961 | 1,387 | 542 | 674 | | 2,603 | 142.72 | 18,238 |
| 1962 | 1,496 | 574 | 811 | | 2,881 | 155.05 | 18,583 |
| 1963 | 1,510 | 632 | 885 | | 3,027 | 159.91 | 18,931 |
| 1964 | 1,702 | 690 | 973 | | 3,365 | 174.45 | 19,291 |
| 1965 | 1,908 | 761 | 1,046 | | 3,715 | 189.11 | 19,644 |
| 1966 | 1,985 | 844 | 1,152 | | 3,981 | 198.88 | 20,015 |
| 1967 | 2,285 | 861 | 1,235 | | 4,381 | 214.99 | 20,378 |
| 1968 | 2,493 | 886 | 1,343 | | 4,722 | 228.10 | 20,701 |
| 1969 | 2,378 | 891 | 1,465 | | 4,734 | 225.42 | 21,001 |
| 1970 | 3,073 | 931 | 1,718 | | 5,722 | 268.68 | 21,297 |
| 1971 | 2,940 | 1,008 | 2,015 | | 5,963 | 276.46 | 21,568 |
| 1972 | 2,956 | 1,085 | 2,367 | | 6,408 | 293.92 | 21,802 |
| 1973 | 3,850 | 1,293 | 3,227 | | 8,370 | 379.69 | 22,043 |
| 1974 | 4,821 | 1,731 | 5,202 | | 11,754 | 525.55 | 22,364 |
| 1975 | 4,796 | 1,898 | 6,653 | | 13,347 | 588.05 | 22,697 |
| 1976 | 5,315 | 2,269 | 8,109 | | 15,693 | 682.51 | 22,993 |
| 1977 | 5,988 | 2,612 | 9,873 | | 18,473 | 794.26 | 23,258 |
| 1978 | 5,682 | 2,986 | 11,578 | 73 | 20,319 | 865.51 | 23,476 |
| 1979 | 7,924 | 3,514 | 14,617 | 81 | 26,135 | 1,104.11 | 23,671 |
| 1980 | 9,666 | 4,201 | 17,944 | 115 | 31,926 | 1,333.79 | 23,936 |
| 1981r | 8,753 | 4,486 | 19,012 | 136 | 32,420 | 1,331.85 | 24,342 |
| 1982 | 6,874 | 3,709 | 23,038 | 215 | 33,837 | 1,373.59 | 24,634 |
| 1983P | 7,238 | 3,604 | 24,963 | 172 | 35,976 | 1,445.40 | 24,890 |

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[1] Other minerals include arseneous trioxide, bentonite, calcium, cesium, diatomite, graphite, ilmenite, indium, magnesium, mica, pumice, rhenium, rhubidium, serpentine, strontium, titanium dioxide for which the value of production is confidential.

P Preliminary; r - Revised.

## TABLE 3. CANADA, VALUE OF MINERAL PRODUCTION BY PROVINCES, TERRITORIES AND MINERAL CLASSES, 1983P

| | Metals | | Industrial Minerals | | Fuels | | Other Minerals[1] | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ($000) | (% of total) | ($000) | (% of total) | ($000) | (% of total) | ($000) | (% of total) | ($000) | (% of total) |
| Alberta | 352 | x | 721,611 | 20.0 | 21,496,250 | 86.1 | - | - | 22,218,213 | 61.8 |
| Ontario | 2,671,512 | 36.9 | 801,046 | 22.2 | 65,108 | 0.3 | 29,030 | 16.9 | 3,566,696 | 9.9 |
| British Columbia | 1,225,964 | 16.9 | 308,856 | 8.6 | 1,291,189 | 5.2 | 721 | 0.4 | 2,826,730 | 7.9 |
| Saskatchewan | 229,739 | 3.2 | 730,276 | 20.3 | 1,774,469 | 7.1 | 1,652 | 1.0 | 2,736,136 | 7.6 |
| Quebec | 1,086,987 | 15.0 | 715,027 | 19.8 | - | - | 114,620 | 66.8 | 1,916,634 | 5.3 |
| Newfoundland | 645,514 | 8.9 | 44,852 | 1.2 | - | - | - | - | 690,366 | 1.9 |
| Manitoba | 414,309 | 5.7 | 86,688 | 2.4 | 131,066 | 0.5 | 5,566 | 3.2 | 637,629 | 1.7 |
| Northwest Territories | 473,573 | 6.5 | 41,025 | 1.1 | 28,856 | 0.1 | 17,583 | 10.2 | 561,037 | 1.6 |
| New Brunswick | 431,155 | 6.0 | 51,734 | 1.4 | 28,948 | 0.1 | 1,836 | 1.1 | 513,673 | 1.4 |
| Nova Scotia | - | - | 101,219 | 2.8 | 146,700 | 0.6 | 582 | 0.3 | 248,501 | 0.7 |
| Yukon | 58,837 | 0.8 | 525 | x | - | - | - | - | 59,362 | 0.2 |
| Prince Edward Island | - | - | 1,500 | x | - | - | - | - | 1,500 | x |
| Total, Canada | 7,237,942 | 100.0 | 3,604,359 | 100.0 | 24,962,586 | 100.0 | 171,590 | 100.0 | 35,976,477 | 100.0 |

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[1] Other minerals include arseneous trioxide, bentonite, calcium, cesium, diatomite, graphite, ilmenite, indium, magnesium, mica, pumice, rhenium, rhubidium, serpentine, strontium, titanium dioxide for which the value of production is confidential.

P Preliminary; - Nil; x - Amount too small to be expressed.

## TABLE 4. CANADA, PRODUCTION OF LEADING MINERALS,

| | Unit of Measure | Nfld. | P.E.I. | Nova Scotia | New Brunswick | Quebec | Ontario |
|---|---|---|---|---|---|---|---|
| Petroleum, crude | 000 $m^3$ | - | - | - | x | - | 85 |
| | $000 | - | - | - | 13 | - | 16,552 |
| Natural gas | million $m^3$ | - | - | - | 2 | - | 448 |
| | $000 | - | - | - | 35 | - | 48,556 |
| Natural gas byproducts | 000 $m^3$ | - | - | - | - | - | - |
| | $000 | - | - | - | - | - | - |
| Copper | 000 t | x | - | - | 9 | 63 | 197 |
| | $000 | 384 | - | - | 19,037 | 132,352 | 412,140 |
| Coal | 000 t | - | - | 3 000 | 550 | - | - |
| | $000 | - | - | 146,700 | 28,900 | - | - |
| Gold | 000 kg | x | - | - | x | 26 | 22 |
| | $000 | 162 | - | - | 2,383 | 435,735 | 362,574 |
| Iron ore | 000 t | 18 123 | - | - | - | 9 980 | 3 664 |
| | $000 | 601,078 | - | - | - | 346,191 | 180,519 |
| Zinc | 000 t | 37 | - | - | 234 | 42 | 283 |
| | $000 | 42,146 | - | - | 269,302 | 48,645 | 325,249 |
| Nickel | 000 t | - | - | - | - | - | 95 |
| | $000 | - | - | - | - | - | 595,165 |
| Uranium (U) | 000 t | - | - | - | - | - | 5 |
| | $000 | - | - | - | - | - | 518,364 |
| Cement | 000 t | .. | - | .. | .. | 2 138 | 2 845 |
| | $000 | 10,575 | - | 8,800 | 11,200 | 124,108 | 229,850 |
| Potash ($K_2O$) | 000 t | - | - | - | .. | - | - |
| | $000 | - | - | - | .. | - | - |
| Sand and gravel | 000 t | 2 900 | 935 | 6 200 | 5 400 | 29 838 | 59 250 |
| | $000 | 9,320 | 1,500 | 15,300 | 7,650 | 47,599 | 142,500 |
| Silver | t | 2 | - | - | 210 | 39 | 347 |
| | $000 | 846 | - | - | 94,965 | 17,866 | 157,026 |
| Sulphur, elemental | 000 t | - | - | .. | - | - | 25 |
| | $000 | - | - | .. | - | - | 2,216 |
| Asbestos | 000 t | 32 | - | - | - | 717 | - |
| | $000 | 16,845 | - | - | - | 315,696 | - |
| Stone | 000 t | 280 | - | 650 | 2 140 | 26 514 | 25 000 |
| | $000 | 1,300 | - | 3,463 | 9,750 | 111,358 | 102,475 |
| Salt | 000 t | - | - | .. | .. | .. | 5 059 |
| | $000 | - | - | .. | .. | .. | 93,180 |
| Lead | 000 t | 2 | - | - | 74 | - | 7 |
| | $000 | 898 | - | - | 43,617 | - | 4,007 |
| Lime | 000 t | - | - | - | .. | 297 | 1 418 |
| | $000 | - | - | - | 3,540 | 21,673 | 89,546 |
| Clay products | $000 | 1,385 | - | 2,225 | 1,260 | 24,482 | 75,430 |
| Molybdenum | 000 t | - | - | - | - | - | - |
| | $000 | - | - | - | - | - | - |
| Total leading minerals | $000 | 684,939 | 1,500 | 176,488[1] | 491,652[1] | 1,625,705[1] | 3,355,349 |
| Total all minerals | $000 | 690,366 | 1,500 | 248,501 | 513,673 | 1,916,634 | 3,566,696 |
| Leading minerals as % of all minerals | | 99.2 | 100.0 | 71.0 | 95.7 | 84.8 | 94.1 |

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[1] Value of salt production excluded.

P Preliminary; - Nil; .. Not available; x Less than 1 unit.

## BY PROVINCES AND TERRITORIES, 1983P

| Manitoba | Saskat-chewan | Alberta | British Columbia | Yukon | N.W.T. | Total Canada |
|---:|---:|---:|---:|---:|---:|---:|
| 714 | 9 319 | 64 464 | 2 119 | - | 173 | 76 874 |
| 131,066 | 1,612,399 | 12,282,894 | 408,504 | - | 19,365 | 14,479,793 |
| - | 1 329 | 61 632 | 5 729 | - | 126 | 69 266 |
| - | 60,415 | 6,227,597 | 277,064 | - | 9,491 | 6,623,158 |
| - | 74 | 17 097 | 237 | - | - | 17 408 |
| - | 10,055 | 2,523,359 | 35,221 | - | - | 2,568,635 |
| 63 | 7 | - | 286 | - | - | 625 |
| 132,008 | 13,676 | - | 597,710 | - | - | 1,307,307 |
| - | 7 500 | 21 400 | 11 800 | - | - | 44 250 |
| - | 91,600 | 462,400 | 570,400 | - | - | 1,300,000 |
| 2 | x | x | 8 | 3 | 9 | 71 |
| 37,903 | 2,573 | 352 | 141,211 | 50,451 | 153,067 | 1,186,411 |
| - | - | - | 615 | - | - | 32 382 |
| - | - | - | 15,586 | - | - | 1,143,380 |
| 46 | 6 | - | 99 | - | 224 | 971 |
| 53,077 | 6,782 | - | 114,153 | - | 257,069 | 1,116,423 |
| 27 | - | - | - | - | - | 122 |
| 171,186 | - | - | - | - | - | 766,351 |
| - | 2 | - | - | - | - | 7 |
| - | 204,363 | - | - | - | - | 722,727 |
| 300 | 200 | 1 260 | 720 | - | - | 7 828 |
| 28,100 | 24,000 | 138,600 | 75,600 | - | - | 650,833 |
| - | 6 203 | - | - | - | - | 6 203 |
| - | 620,912 | - | - | - | - | 620,912 |
| 9 850 | 7 700 | 42 500 | 28 300 | 420 | 6 000 | 199 293 |
| 26,575 | 19,000 | 116,000 | 88,860 | 525 | 39,780 | 514,609 |
| 23 | 5 | - | 411 | 18 | 51 | 1 106 |
| 10,575 | 2,222 | - | 185,793 | 8,155 | 22,993 | 500,441 |
| - | - | 6 015 | 287 | - | - | 6 327 |
| - | - | 413,393 | 12,510 | - | - | 428,119 |
| - | - | - | 80 | - | - | 829 |
| - | - | - | 69,739 | - | - | 402,280 |
| 2 400 | - | 125 | 4 950 | - | 309 | 62 359 |
| 11,800 | - | 1,600 | 26,403 | - | 1,245 | 269,394 |
| - | 425 | 1 195 | - | - | - | 8 590 |
| - | 20,821 | 15,071 | - | - | - | 174,261 |
| x | - | - | 108 | x | 68 | 259 |
| 183 | - | - | 63,503 | 231 | 40,444 | 152,883 |
| .. | - | 159 | 129 | - | - | 2 126 |
| 5,436 | - | 10,717 | 8,726 | - | - | 139,638 |
| 1,900 | 3,610 | 12,565 | 4,500 | - | - | 127,357 |
| - | - | - | 11 | - | - | 11 |
| - | - | - | 103,651 | - | - | 103,651 |
| 609,809 | 2,692,428 | 22,204,548 | 2,799,134 | 59,362 | 543,454 | 35,289,563 |
| 637,629 | 2,736,136 | 22,218,213 | 2,826,730 | 59,362 | 561,037 | 35,976,477 |
| 95.6 | 98.4 | 99.9 | 99.0 | 100.0 | 96.9 | 98.1 |

TABLE 5. CANADA, PERCENTAGE CONTRIBUTION OF LEADING MINERALS TO TOTAL VALUE OF MINERAL PRODUCTION, 1977-83

| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983P |
|---|---|---|---|---|---|---|---|
| Oil, crude | 26.4 | 28.7 | 28.6 | 28.4 | 29.2 | 36.0 | 40.2 |
| Natural gas | 18.5 | 19.4 | 18.6 | 19.3 | 19.8 | 21.5 | 18.4 |
| Natural gas byproduct | 5.3 | 5.3 | 5.5 | 5.7 | 6.5 | 6.8 | 7.1 |
| Copper | 6.3 | 5.4 | 5.8 | 5.8 | 4.7 | 3.5 | 3.6 |
| Coal | 3.3 | 3.8 | 3.3 | 2.9 | 3.3 | 3.8 | 3.6 |
| Gold | 1.5 | 1.9 | 2.3 | 3.7 | 2.8 | 2.9 | 3.3 |
| Iron ore | 7.5 | 6.0 | 6.9 | 5.3 | 5.4 | 3.6 | 3.2 |
| Zinc | 4.5 | 4.0 | 4.1 | 2.7 | 3.4 | 3.1 | 3.1 |
| Nickel | 6.6 | 3.1 | 3.2 | 4.7 | 3.8 | 1.8 | 2.1 |
| Uranium (U) | 1.9 | 3.1 | 2.4 | 2.2 | 2.5 | 2.5 | 2.0 |
| Cement | 2.3 | 2.8 | 2.5 | 1.8 | 2.1 | 2.0 | 1.8 |
| Potash ($K_2O$) | 2.2 | 2.5 | 2.8 | 3.2 | 3.1 | 1.9 | 1.7 |
| Sand and gravel | 2.0 | 2.1 | 1.8 | 1.6 | 1.6 | 1.6 | 1.4 |
| Silver | 1.1 | 1.2 | 1.8 | 2.6 | 1.4 | 1.2 | 1.4 |
| Sulphur, elemental | 0.4 | 0.5 | 0.6 | 1.4 | 2.0 | 1.7 | 1.2 |
| Asbestos | 3.1 | 2.6 | 2.3 | 1.9 | 1.7 | 1.1 | 1.1 |
| Stone | 1.6 | 1.6 | 1.3 | 1.1 | 1.0 | 0.8 | 0.7 |
| Salt | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 |
| Lead | 1.1 | 1.3 | 1.6 | 0.9 | 0.8 | 0.6 | 0.4 |
| Lime | 0.4 | 0.4 | 0.3 | 0.4 | 0.5 | 0.4 | 0.4 |
| Clay products | 0.6 | 0.5 | 0.5 | 0.3 | 0.4 | 0.3 | 0.4 |
| Molybdenum | 0.8 | 0.9 | 1.3 | 0.9 | 0.9 | 0.5 | 0.3 |
| Other minerals | 2.1 | 2.4 | 2.1 | 2.8 | 2.7 | 1.9 | 1.9 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

P Preliminary.

**TABLE 6. CANADA, VALUE OF MINERAL PRODUCTION BY PROVINCES AND TERRITORIES, 1977-83**

| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983P |
|---|---|---|---|---|---|---|---|
| | ($ million) | | | | | | |
| Alberta | 8,576 | 10,087 | 12,899 | 16,379 | 17,559 | 20,913 | 22,218 |
| Ontario | 2,980 | 2,698 | 3,265 | 4,640 | 4,160 | 3,148 | 3,567 |
| British Columbia | 1,687 | 1,883 | 2,677 | 2,795 | 2,822 | 2,769 | 2,827 |
| Saskatchewan | 1,208 | 1,582 | 1,874 | 2,315 | 2,293 | 2,313 | 2,736 |
| Quebec | 1,675 | 1,796 | 2,165 | 2,467 | 2,420 | 2,065 | 1,917 |
| Newfoundland | 867 | 675 | 1,125 | 1,036 | 1,030 | 647 | 690 |
| Manitoba | 564 | 459 | 653 | 803 | 642 | 530 | 638 |
| Northwest Territories | 256 | 310 | 435 | 425 | 447 | 503 | 561 |
| New Brunswick | 289 | 339 | 480 | 373 | 531 | 498 | 514 |
| Nova Scotia | 159 | 211 | 210 | 247 | 269 | 281 | 249 |
| Yukon | 210 | 219 | 299 | 361 | 236 | 169 | 59 |
| Prince Edward Island | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Total | 18,473 | 20,261 | 26,084 | 31,842 | 32,410 | 33,837 | 35,976 |

P Preliminary.

**TABLE 7. CANADA, PERCENTAGE CONTRIBUTION OF PROVINCES AND TERRITORIES TO TOTAL VALUE OF MINERAL PRODUCTION, 1977-83**

| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983P |
|---|---|---|---|---|---|---|---|
| Alberta | 46.4 | 49.8 | 49.5 | 51.4 | 54.2 | 61.8 | 61.8 |
| Ontario | 16.1 | 13.3 | 12.5 | 14.6 | 12.8 | 9.3 | 9.9 |
| British Columbia | 9.1 | 9.3 | 10.3 | 8.8 | 8.7 | 8.2 | 7.9 |
| Saskatchewan | 6.5 | 7.8 | 7.2 | 7.2 | 7.0 | 6.3 | 7.6 |
| Quebec | 9.1 | 8.9 | 8.3 | 7.7 | 7.5 | 6.1 | 5.3 |
| Newfoundland | 4.7 | 3.3 | 4.3 | 3.3 | 3.2 | 1.9 | 1.9 |
| Manitoba | 3.1 | 2.3 | 2.5 | 2.5 | 2.0 | 1.6 | 1.7 |
| Northwest Territories | 1.4 | 1.5 | 1.7 | 1.3 | 1.4 | 1.5 | 1.6 |
| New Brunswick | 1.6 | 1.7 | 1.8 | 1.2 | 1.6 | 1.5 | 1.4 |
| Nova Scotia | 0.9 | 1.0 | 0.8 | 0.8 | 0.8 | 0.8 | 0.7 |
| Yukon | 1.1 | 1.1 | 1.1 | 1.1 | 0.7 | 0.5 | 0.2 |
| Prince Edward Island | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | x |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

P Preliminary. x - Too small to be expressed.

TABLE 8. CANADA'S WORLD ROLE AS A PRODUCER OF

| | | World |
|---|---|---|
| **Zinc** (mine production) | 000 t | 6 503 |
| | % of world total | |
| **Potash** ($K_2O$ equivalent) | 000 t | 25 950 |
| | % of world total | |
| **Uranium** (U concentrates) | t | 48 662 |
| | % of world total | |
| **Asbestos** | 000 t | 4 668 |
| | % of world total | |
| **Sulphur, elemental** | 000 t | 45 904 |
| | % of world total | |
| **Titanium concentrates** (ilmenite) | 000 t | 4 577 |
| | % of world total | |
| **Nickel** (mine production) | 000 t | 625 |
| | % of world total | |
| **Molybdenum** (Mo content) | 000 t | 96 |
| | % of world total | |
| **Aluminum** (primary metal) | 000 t | 13 989 |
| | % of world total | |
| **Gypsum** | 000 t | 73 119 |
| | % of world total | |
| **Gold** (mine production) | t | 1 278 |
| | % of world total | |
| **Platinum group metals** (mine production) | kg | 199 466 |
| | % of world total | |
| **Silver** (mine production) | t | 11 725.7 |
| | % of world total | |
| **Lead** (mine production) | 000 t | 3 581 |
| | % of world total | |
| **Cadmium** (smelter production) | t | 16 455 |
| | % of world total | |
| **Copper** (mine production) | 000 t | 8 220 |
| | % of world total | |
| **Iron ore** | 000 t | 803 287 |
| | % of world total | |

P Preliminary; ᵉ Estimated.

## CERTAIN IMPORTANT MINERALS, 1982P

| Rank of Six Leading Countries | | | | | |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| **Canada** | U.S.S.R. | Australia | Peru | U.S.A. | Japan |
| 1 189 | 1 020$^e$ | 665 | 541 | 330 | 251 |
| 18.3 | 15.7 | 10.2 | 8.3 | 5.1 | 3.9 |
| U.S.S.R. | **Canada** | East Germany | West Germany | France | U.S.A. |
| 9 000 | 5 196 | 3 500 | 2 500 | 1 823 | 1 784 |
| 34.7 | 20.0 | 13.5 | 9.5 | 7.0 | 6.9 |
| U.S.A. | **Canada** | South Africa | Australia | Nigeria | Namibia |
| 12 156.3 | 9 625.4 | 6 858.3 | 5 250.8 | 5 023.1 | 4 453.4 |
| 25.0 | 19.8 | 14.1 | 10.8 | 10.3 | 9.2 |
| U.S.S.R. | **Canada** | South Africa | Zimbabwe | Brazil | China |
| 2 800 | 834.2 | 211.9 | 194.4 | 144.8 | 140.0 |
| 60.0 | 17.9 | 4.5 | 4.2 | 3.1 | 3.0 |
| U.S.A. | **Canada** | Poland | U.S.S.R. | Japan | France |
| 8 878.6 | 5 715.3 | 4 935 | 3 556 | 2 268.0 | 1 905.1 |
| 19.3 | 12.5 | 10.8 | 7.7 | 5.4 | 4.2 |
| Australia | **Canada** | Norway | U.S.S.R. | South Africa | U.S.A. |
| 1 300 | 750 | 608 | 475 | 420 | 263 |
| 28.4 | 16.4 | 13.3 | 10.4 | 9.2 | 5.7 |
| U.S.S.R. | **Canada** | Australia | New Caledonia | Indonesia | Cuba |
| 170.0 | 88.7 | 88.6 | 60.1 | 48.5 | 37.6 |
| 27.2 | 14.2 | 14.2 | 9.6 | 7.8 | 6.0 |
| U.S.A. | Chile | **Canada** | U.S.S.R. | Mexico | Peru |
| 37.7 | 20.0 | 16.5 | 11.0 | 5.2 | 2.6 |
| 39.4 | 20.9 | 17.3 | 11.5 | 5.4 | 2.7 |
| U.S.A. | U.S.S.R. | **Canada** | West Germany | Norway | France |
| 3 274.0 | 2 400.0 | 1 118.1 | 722.8 | 645.1 | 390.4 |
| 23.4 | 17.2 | 8.0 | 5.2 | 4.6 | 2.8 |
| U.S.A. | France | **Canada** | U.S.S.R. | Spain | Iran |
| 9 559.9 | 6 168.9 | 5 726.2 | 5 443.1 | 5 261.7 | 4 989.5 |
| 13.1 | 8.4 | 7.8 | 7.4 | 7.2 | 6.8 |
| South Africa | U.S.S.R. | **Canada** | China | U.S.A. | Brazil |
| 664.2 | 265.9 | 64.7 | 56.0 | 45.0 | 45.0 |
| 52.0 | 20.8 | 5.1 | 4.4 | 3.5 | 3.5 |
| U.S.S.R. | South Africa | **Canada** | Japan | Australia | Colombia |
| 108 862.2 | 80 869.0 | 7 105.0 | 1 345.6 | 436.4 | 373.2 |
| 54.6 | 40.5 | 3.6 | 0.7 | 0.2 | 0.2 |
| Peru | U.S.S.R. | Mexico | **Canada** | U.S.A. | Australia |
| 1 691.0 | 1 595.0 | 1 550.2 | 1 313.6 | 1 251.6 | 906.9 |
| 14.4 | 13.6 | 13.2 | 11.2 | 10.7 | 7.7 |
| U.S.S.R. | U.S.A. | Australia | **Canada** | Peru | Mexico |
| 575.0 | 522.9 | 455.3 | 341.2 | 201.4 | 167.9 |
| 16.1 | 14.6 | 12.7 | 9.5 | 5.6 | 4.7 |
| U.S.S.R. | Japan | U.S.A. | **Canada** | West Germany | Australia |
| 2 800 | 2 021.2 | 1 351.8 | 1 058.2 | 1 030.1 | 1 010.2 |
| 16.7 | 12.1 | 8.1 | 6.6 | 6.1 | 6.0 |
| Chile | U.S.S.R. | U.S.A. | **Canada** | Zambia | Zaire |
| 1 240.7 | 1 180.0 | 1 139.6 | 612.4 | 529.6 | 502.8 |
| 15.1 | 14.4 | 13.9 | 7.4 | 6.4 | 6.1 |
| U.S.S.R. | Brazil | Australia | China | **Canada** | India |
| 243 952.9 | 110 037.9 | 88 294.5 | 70 005.6 | 41 861.1 | 40 946.7 |
| 30.4 | 13.7 | 11.0 | 8.7 | 5.2 | 5.1 |

## TABLE 9. CANADA, GROSS DOMESTIC PRODUCT BY INDUSTRY IN CONSTANT 1971 DOLLARS, 1977-83

| | 1977 | 1978 | 1979$^r$ | 1980$^r$ | 1981$^r$ | 1982 | 1983$^P$ |
|---|---|---|---|---|---|---|---|
| | | | | ($ million) | | | |
| **Goods producing industries** | | | | | | | |
| Agriculture | 3,069.7 | 2,996.5 | 2,702.8 | 2,921.3 | 3,158.5 | 3,250.2 | 3,311.0 |
| Forestry | 741.9 | 794.9 | 800.8 | 826.7 | 759.0 | 621.8 | 761.5 |
| Fishing and trapping | 162.3 | 179.5 | 182.8 | 172.5 | 188.1 | 183.2 | 181.9 |
| Mining[1] | 3,337.3 | 3,015.1 | 3,347.9 | 3,465.4 | 3,290.8 | 2,889.1 | 3,062.8 |
| Manufacturing | 23,901.6 | 25,139.9 | 26,587.7 | 25,830.9 | 26,235.8 | 23,066.7 | 24,496.2 |
| Construction | 6,856.2 | 6,706.0 | 7,108.6 | 7,042.0 | 7,477.5 | 6,640.6 | 6,457.4 |
| Electrical power, gas and water utilities | 3,311.3 | 3,521.6 | 3,792.6 | 3,832.4 | 3,900.5 | 3,906.3 | 4,051.3 |
| Total | 41,380.3 | 42,353.6 | 44,523.2 | 44,091.2 | 45,010.2 | 40,557.9 | 42,322.1 |
| **Service producing industries** | | | | | | | |
| Transportation, storage and communication | 10,972.8 | 11,462.3 | 15,905.1 | 16,419.9 | 16,882.1 | 16,377.1 | 16,733.4 |
| Trade | 13,710.4 | 14,206.5 | 14,998.2 | 15,011.8 | 15,136.4 | 14,121.7 | 14,543.3 |
| Finance, insurance and real estate | 13,444.8 | 14,119.9 | 14,768.5 | 15,331.7 | 16,019.4 | 16,108.4 | 16,324.9 |
| Community, business and personnel services | 21,096.3 | 21,888.1 | 22,007.6 | 22,744.4 | 23,876.1 | 23,866.3 | 24,171.5 |
| Public administration and defense | 7,736.2 | 7,927.5 | 7,886.7 | 7,980.0 | 8,137.0 | 8,404.9 | 8,517.0 |
| Total | 66,960.5 | 69,604.3 | 75,566.1 | 77,487.8 | 80,051.0 | 78,878.4 | 80,290.1 |
| Grand total | 108,340.8 | 111,957.9 | 120,089.3 | 121,579.0 | 125,061.2 | 119,436.3 | 122,612.2 |

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[1] Cement, lime, clay and clay products (domestic clays) industries are included under "manufacturing".
P Preliminary; $^r$ Revised.

## TABLE 10. CANADA, CENSUS VALUE ADDED, TOTAL ACTIVITY, MINING AND MINERAL MANUFACTURING INDUSTRIES, 1976-82

| | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|
| | | | | ($ million) | | | |
| **Mining** | | | | | | | |
| Metallic minerals | | | | | | | |
| Gold-quartz | 113.7 | 152.0 | 207.6 | 322.8 | 588.8 | 519.0 | 566.2 |
| Silver-lead-zinc | 233.7 | 279.8 | 372.7 | 671.9 | 513.6 | 380.3 | 351.1 |
| Nickel-copper-gold-silver | 1,488.8 | 1,244.3 | 1,288.5 | 2,469.7 | 2,992.2 | 2,007.9 | 1,144.9 |
| Iron | 732.1 | 807.3 | 717.0 | 1,022.2 | 1,005.0 | 1,036.0 | 761.4 |
| Uranium | 195.8 | 300.1 | 501.7 | 525.4 | 559.3 | 865.8 | 600.1 |
| Miscellaneous metal mines | 74.2 | 118.0 | 138.6 | 179.7 | 243.3 | 150.2 | 73.7 |
| Total | 2,838.4 | 2,901.4 | 3,226.1 | 5,191.6 | 5,902.2 | 4,959.3 | 3,497.4 |
| Industrial minerals | | | | | | | |
| Asbestos | 373.2 | 474.8 | 401.6 | 456.8 | 473.4 | 431.5 | 267.3 |
| Gypsum | 15.8 | 21.0 | 25.9 | 27.5 | 26.9 | 31.3 | 26.6 |
| Peat | 23.7 | 27.4 | 33.7 | 38.8 | 42.7 | 47.8 | 41.1 |
| Potash | 262.1 | 301.4 | 360.2 | 613.5 | 900.4 | 889.7 | 488.5 |
| Sand and gravel | 99.0 | 91.3 | 85.8 | 91.5 | 92.0 | 98.3 | 75.6 |
| Stone | 111.0 | 106.1 | 110.2 | 121.7 | 123.4 | 122.5 | 109.4 |
| Miscellaneous nonmetals | 113.1 | 116.5 | 122.6 | 140.1 | 152.8 | 171.0 | 183.5 |
| Total | 997.8 | 1,138.4 | 1,139.9 | 1,489.8 | 1,811.5 | 1,791.9 | 1,192.0 |
| Fuels | | | | | | | |
| Coal | 474.3 | 508.5 | 566.8 | 658.6 | 621.6 | 671.1 | 838.0 |
| Petroleum and natural gas | 7,052.0 | 8,698.3 | 10,078.6 | 12,554.1 | 14,917.3 | 15,924.6 | 18,915.5 |
| Total | 7,526.3 | 9,206.9 | 10,645.4 | 13,212.7 | 15,538.9 | 16,595.7 | 19,753.5 |
| Total mining industry | 11,362.5 | 13,246.7 | 15,011.4 | 19,894.1 | 23,252.6 | 23,347.0 | 24,442.9 |
| **Mineral manufacturing** | | | | | | | |
| Primary metal industries | | | | | | | |
| Iron and steel mills | 1,498.8 | 1,677.6 | 1,924.9 | 2,424.3 | 2,537.9 | 2,750.9 | 2,149.9 |
| Steel pipe & tube mills | 148.8 | 160.3 | 225.1 | 280.4 | 297.6 | 378.3 | 320.3 |
| Iron foundries | 241.9 | 257.7 | 273.8 | 298.2 | 266.9 | 266.0 | 279.9 |
| Smelting and refining | 812.7 | 1,176.1 | 1,387.2 | 1,401.0 | 1,976.9 | 1,808.9 | 1,493.0 |
| Aluminum rolling, casting and extruding | 149.4 | 193.7 | 154.3 | 249.0 | 273.5 | 292.8 | 289.9 |
| Copper and alloy rolling, casting and extruding | 71.4 | 78.5 | 93.1 | 131.5 | 103.7 | 129.3 | 101.6 |
| Metal rolling, casting and extruding, nes | 113.3 | 110.2 | 136.2 | 198.9 | 203.6 | 210.4 | 169.2 |
| Total | 3,036.3 | 3,654.0 | 4,194.7 | 4,983.3 | 5,660.1 | 5,836.6 | 4,803.8 |

(continued on following page)

**TABLE 10.** (cont'd)

| | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|
| | | | | ($ million) | | | |
| **Mineral manufacturing** (cont'd) | | | | | | | |
| Nonmetallic mineral products industries | | | | | | | |
| Cement manufacturers | 249.1 | 275.0 | 319.9 | 388.8 | 357.3 | 422.2 | 387.4 |
| Lime manufacturers | 30.0 | 36.6 | 44.6 | 49.3 | 59.5 | 62.8 | 60.1 |
| Concrete products manufacturers | 282.1 | 273.5 | 309.3 | 328.7 | 324.6 | 378.5 | 349.7 |
| Ready-mix concrete manufacturers | 282.6 | 292.8 | 317.3 | 341.6 | 352.4 | 430.1 | 388.6 |
| Clay products (domestic clay) | 65.9 | 69.6 | 73.6 | 87.5 | 84.6 | 82.0 | 57.1 |
| Clay products (imported clay) | 39.1 | 39.8 | 43.1 | 44.9 | 51.6 | 50.9 | 37.9 |
| Refractories manufacturers | 44.4 | 32.5 | 45.3 | 66.6 | 73.6 | 54.5 | 61.8 |
| Stone products manufacturers | 16.3 | 19.6 | 22.4 | 28.2 | 33.2 | 40.9 | 39.5 |
| Glass manufacturers | 205.1 | 199.2 | 266.8 | 294.9 | 308.1 | 364.6 | 339.6 |
| Glass products manufacturers | 87.4 | 96.6 | 122.9 | 141.0 | 143.6 | 141.0 | 144.9 |
| Abrasive manufacturers | 55.1 | 64.1 | 70.6 | 79.4 | 92.1 | 95.9 | 80.4 |
| Other nonmetallic mineral products industries | 270.2 | 253.6 | 341.0 | 375.2 | 370.7 | 388.0 | 325.4 |
| Total | 1,627.3 | 1,652.9 | 1,976.8 | 2,226.2 | 2,251.3 | 2,510.5 | 2,272.4 |
| Petroleum and coal products industries | | | | | | | |
| Petroleum refining | 945.8 | 1,206.7 | 1,180.4 | 1,390.9 | 1,750.1 | 2,641.5 | 2,108.4 |
| Manufacturers of lubricating oil and greases | 32.6 | 36.8 | 36.9 | 38.3 | 26.7 | 35.0 | 31.7 |
| Other petroleum and coal products industries | 45.7 | 44.4 | 33.1 | 30.5 | 36.0 | 39.3 | 39.9 |
| Total | 1,024.2 | 1,287.9 | 1,250.4 | 1,459.8 | 1,812.8 | 2,715.8 | 2,180.1 |
| Total mineral manufacturing | 5,687.8 | 6,594.8 | 7,421.9 | 8,669.2 | 9,724.2 | 11,062.9 | 9,256.2 |
| Total mining and mineral manufacturing | 17,050.3 | 19,841.5 | 22,433.3 | 28,563.3 | 32,976.9 | 34,409.9 | 33,699.2 |

nes Not elsewhere specified.

TABLE 11. CANADA, INDEXES OF GROSS DOMESTIC PRODUCT OF INDUSTRIAL PRODUCTION, MINING AND MINERAL MANUFACTURING, 1969-83 (1971=100)

| | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979r | 1980r | 1981r | 1982r | 1983p |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total industrial production | 93.6 | 94.9 | 100.0 | 107.6 | 119.0 | 122.8 | 115.5 | 122.2 | 125.3 | 129.9 | 137.9 | 135.9 | 137.1 | 122.5 | 129.7 |
| Total mining | 86.9 | 98.7 | 100.0 | 104.4 | 117.8 | 114.0 | 100.9 | 103.1 | 106.1 | 95.8 | 106.4 | 110.2 | 104.6 | 91.8 | 97.2 |
| Metals | | | | | | | | | | | | | | | |
| All metals | 88.4 | 105.4 | 100.0 | 94.3 | 105.7 | 101.8 | 91.2 | 96.7 | 99.5 | 73.8 | 79.1 | 85.9 | 83.9 | 63.7 | 72.1 |
| Placer gold and gold quartz mines | 118.2 | 105.3 | 100.0 | 90.1 | 80.0 | 68.4 | 67.4 | 69.1 | 68.2 | 65.5 | 59.8 | 59.0 | 60.2 | 81.7 | 105.1 |
| Iron mines | 91.9 | 116.1 | 100.0 | 78.7 | 97.4 | 80.4 | 71.4 | 104.6 | 94.7 | 41.5 | 82.2 | 77.4 | 78.8 | 53.6 | 51.4 |
| Other metal mines | 85.3 | 103.0 | 100.0 | 98.6r | 109.3r | 109.3r | 97.7r | 96.0r | 102.4r | 82.8 | 81.9 | 92.6 | 89.4 | 67.9 | 78.4 |
| Fuels | | | | | | | | | | | | | | | |
| All fuels | 80.8 | 92.6 | 100.0 | 114.7 | 130.1 | 124.7 | 112.4 | 107.5 | 108.6 | 109.5 | 123.0 | 121.3 | 113.5 | 113.1 | 116.8 |
| Coal | 68.4 | 87.5 | 100.0 | 105.4 | 115.5 | 116.8 | 137.5 | 128.5 | 125.2 | 138.9 | 167.8 | 184.5 | 193.7 | 204.4 | 208.8 |
| Crude oil and natural gas | 81.7 | 93.0 | 100.0 | 115.4 | 131.2 | 125.3 | 110.5 | 105.9 | 107.3 | 107.3 | 119.6 | 116.5 | 107.5 | 106.2 | 109.9 |
| Nonmetals | | | | | | | | | | | | | | | |
| All metals | 92.8 | 95.0 | 100.0 | 99.7 | 107.8 | 119.7 | 88.9 | 103.6 | 109.4 | 103.2 | 116.6 | 113.3 | 106.5 | 82.7 | 88.6 |
| Asbestos | 89.8 | 95.2 | 100.0 | 101.0 | 102.1 | 102.0 | 63.7 | 85.5 | 85.5 | 64.6 | 69.9 | 63.4 | 53.8 | 37.7 | 36.5 |
| Mineral manufacturing | | | | | | | | | | | | | | | |
| Primary metals | 94.9 | 100.9 | 100.0 | 101.3 | 112.2 | 118.7 | 107.0 | 105.6 | 113.2 | 119.5 | 121.6 | 121.2 | 121.3 | 97.4 | 106.8 |
| Nonmetallic mineral products | 90.5 | 86.6 | 100.0 | 109.1 | 119.5 | 125.2 | 117.7 | 120.5 | 119.4 | 127.3 | 134.6 | 122.7 | 119.9 | 95.3 | 104.8 |
| Petroleum and coal products | 92.1 | 94.4 | 100.0 | 115.3 | 136.1 | 136.8 | 130.9 | 120.0 | 112.1 | 110.8 | 97.7 | 97.6 | 102.9 | 89.6 | 86.8 |

p Preliminary; r Revised.

TABLE 12. CANADA, INDEXES OF GROSS DOMESTIC PRODUCT BY INDUSTRIES, 1969-83 (1971=100)

| | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979$^{r}$ | 1980$^{r}$ | 1981$^{r}$ | 1982$^{r}$ | 1983P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gross domestic product, all industries | 92.2 | 94.4 | 100.0 | 105.9 | 114.1 | 119.3 | 120.4 | 126.4 | 130.1 | 134.5 | 144.2 | 146.0 | 150.2 | 143.4 | 147.3 |
| Agriculture | 90.6 | 89.0 | 100.0 | 88.7 | 96.9 | 89.5 | 103.0 | 109.3 | 113.9 | 111.2 | 100.3 | 108.3 | 117.2 | 120.5 | 122.8 |
| Forestry | 102.4 | 103.3 | 100.0 | 105.7 | 113.7 | 112.1 | 97.8 | 105.4 | 110.8 | 118.7 | 119.6 | 123.5 | 113.4 | 92.9 | 113.8 |
| Fishing and trapping | 102.6 | 105.4 | 100.0 | 95.7 | 101.6 | 90.2 | 85.8 | 98.0 | 110.1 | 121.8 | 123.8 | 116.8 | 127.9 | 124.1 | 123.5 |
| Mines (incl. milling), quarries and oil wells | 86.9 | 98.7 | 100.0 | 104.4 | 117.8 | 114.0 | 100.9 | 103.1 | 106.1 | 95.8 | 106.4 | 110.2 | 104.6 | 91.8 | 97.4 |
| Electric power, gas and water utilities | 85.4 | 93.3 | 100.0 | 111.1 | 120.3 | 130.1 | 130.5 | 142.0 | 150.9 | 160.5 | 172.8 | 174.7 | 177.8 | 178.0 | 184.6 |
| Manufacturing | 95.8 | 94.5 | 100.0 | 107.7 | 119.1 | 123.4 | 116.2 | 123.1 | 125.5 | 132.0 | 140.1 | 136.1 | 138.3 | 121.6 | 129.1 |
| Construction | 92.5 | 90.9 | 100.0 | 103.0 | 106.1 | 110.3 | 116.0 | 119.6 | 117.3 | 114.7 | 121.6 | 120.5 | 127.9 | 113.6 | 110.5 |
| Transportation, storage and communications | 89.0 | 94.2 | 100.0 | 108.5 | 117.9 | 125.0 | 126.5 | 134.2 | 141.6 | 148.6 | 204.9 | 211.5 | 217.4 | 210.9 | 215.5 |
| Trade | 91.7 | 93.2 | 100.0 | 109.9 | 119.8 | 129.5 | 132.5 | 138.0 | 139.8 | 144.9 | 153.0 | 153.1 | 154.4 | 144.0 | 148.3 |
| Community, business and personal service | 91.6 | 95.5 | 100.0 | 104.8 | 109.5 | 115.8 | 121.1 | 127.3 | 131.2 | 136.1 | 136.9 | 141.5 | 148.5 | 148.4 | 150.3 |
| Finance, insurance and real estate | 92.4 | 94.6 | 100.0 | 105.3 | 114.0 | 120.9 | 125.9 | 132.3 | 140.2 | 147.3 | 154.1 | 159.9 | 167.1 | 168.0 | 170.3 |
| Public administration and defence | 91.6 | 95.2 | 100.0 | 104.2 | 109.7 | 113.9 | 119.4 | 123.0 | 125.7 | 128.9 | 128.2 | 129.8 | 132.3 | 136.7 | 138.5 |

P Preliminary; $^{r}$ Revised.

## TABLE 13. CANADA, GROSS DOMESTIC PRODUCT FOR SELECTED INDUSTRIES BY PROVINCE, 1981

| | Newfoundland | Prince Edward Island | Nova Scotia | New Brunswick | Quebec | Ontario | Manitoba | Saskatchewan | Alberta | British Columbia | Yukon and Northwest Territories | Canada |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | ($ million) | | | | | | |
| Agriculture | 17.5 | 90.2 | 112.9 | 86.4 | 1,315.8 | 2,554.1 | 902.2 | 2,468.1 | 2,128.5 | 506.0 | .. | 10,181.7 |
| Forestry | 54.0 | 0.1 | 30.0 | 126.6 | 389.7 | 355.1 | 16.5 | 34.4 | 53.8 | 970.0 | - | 2,030.2 |
| Fishing, Hunting and Trapping | 117.6 | 22.5 | 185.7 | 39.4 | 40.4 | 35.0 | 17.5 | 6.8 | 7.9 | 168.0 | 4.8 | 645.6 |
| Mining[1] | 444.6 | - | 126.8 | 169.8 | 1,059.9 | 2,317.7 | 397.5 | 1,329.2 | 9,782.4 | 1,484.5 | 220.4 | 17,288.7 |
| Manufacturing | 463.6 | 63.0 | 1,074.5 | 884.6 | 17,208.6 | 31,329.6 | 1,760.2 | 679.1 | 3,379.2 | 5,699.1 | 6.0 | 62,548.2 |
| Construction | 280.1 | 46.4 | 421.7 | 339.4 | 3,317.8 | 4,762.4 | 474.5 | 820.9 | 4,530.1 | 2,967.1 | 279.2 | 18,239.6 |
| Electric power, gas and water utilities | 204.2 | 14.5 | 194.8 | 249.3 | 2,869.9 | 3,293.9 | 431.8 | 256.8 | 833.6 | 1,003.8 | 45.4 | 9,398.0 |
| Goods-producing industries | 1,581.6 | 236.7 | 2,146.4 | 1,895.5 | 26,202.1 | 44,647.8 | 4,000.2 | 5,595.3 | 20,715.5 | 12,798.5 | 555.8 | 120,332.0 |

[1] Cement, lime, clay and clay products (domestic clays) industries are included under "manufacturing".

x Confidential; .. Not available; - Nil.

TABLE 14. CANADA, GROSS DOMESTIC PRODUCT FOR MINING BY PROVINCE, 1975-81

| | New-found-land | Prince Edward Island | Nova Scotia | New Brunswick | Quebec | Ontario | Manitoba | Saskat-chewan | Alberta | British Columbia | Yukon and Northwest Terri-tories | Canada |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | ($ million) | | | | | | |
| 1975 | 212.3 | - | 63.5 | 66.9 | 503.2 | 1,128.9 | 170.3 | 445.3 | 3,474.6 | 613.2 | 104.8 | 6,771.7 |
| 1976 | 309.6 | - | 80.5 | 59.2 | 677.7 | 1,261.1 | 207.5 | 504.5 | 3,860.6 | 849.1 | 68.0 | 7,865.9 |
| 1977 | 346.6 | - | 113.4 | 65.6 | 737.1 | 1,203.1 | 125.4 | 660.5 | 4,804.2 | 866.9 | 155.2 | 9,064.6 |
| 1978 | 230.7 | - | 103.9 | 113.2 | 708.3 | 1,217.0 | 184.9 | 861.4 | 5,245.9 | 924.5 | 215.2 | 9,794.3 |
| 1979 | 459.2 | - | 111.1 | 206.4 | 1,175.2 | 1,519.9 | 426.4 | 1,045.3 | 7,120.6 | 1,507.3 | 262.2 | 13,921.7 |
| 1980 | 410.3 | - | 120.0 | 88.6 | 1,123.6 | 2,806.1 | 522.6 | 1,333.0 | 9,641.6 | 1,464.3 | 368.0 | 17,851.2 |
| 1981 | 444.6 | - | 126.8 | 169.8 | 1,059.9 | 2,317.7 | 397.5 | 1,329.2 | 9,782.4 | 1,484.5 | 220.4 | 17,288.7 |

- Nil.

### TABLE 15. CANADA, VALUE OF EXPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, 1977-83

| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983P |
|---|---|---|---|---|---|---|---|
| | | | ($ million) | | | | |
| **Ferrous** | | | | | | | |
| Crude material | 1,114.9 | 854.5 | 1,469.5 | 1,342.9 | 1,540.0 | 1,098.3 | 1,054.3 |
| Fabricated material | 1,242.9 | 1,696.0 | 1,947.6 | 2,358.0 | 2,664.9 | 2,299.2 | 2,011.6 |
| Total | 2,357.9 | 2,550.6 | 3,417.1 | 3,701.1 | 4,205.0 | 3,397.5 | 3,065.9 |
| **Nonferrous** | | | | | | | |
| Crude material | 1,614.9 | 1,549.2 | 2,425.1 | 2,866.6 | 2,544.0 | 2,088.8 | 1,845.9 |
| Fabricated material | 2,578.4 | 3,360.9 | 3,807.1 | 6,273.8 | 5,615.6 | 4,977.9 | 5,624.5 |
| Total | 4,193.4 | 4,910.1 | 6,232.1 | 9,140.4 | 8,159.6 | 7,066.7 | 7,470.5 |
| **Nonmetals** | | | | | | | |
| Crude material | 1,276.1 | 1,369.7 | 1,715.3 | 2,305.0 | 2,618.7 | 2,171.1 | 2,103.5 |
| Fabricated material | 253.6 | 377.2 | 455.9 | 412.5 | 439.7 | 409.3 | 424.8 |
| Total | 1,529.6 | 1,746.8 | 2,171.2 | 2,717.5 | 3,058.3 | 2,580.5 | 2,528.3 |
| **Mineral fuels** | | | | | | | |
| Crude material | 4,428.9 | 4,514.9 | 6,128.9 | 7,816.8 | 8,022.0 | 8,752.4 | 8,727.9 |
| Fabricated material | 649.1 | 1,022.7 | 1,885.3 | 2,324.2 | 2,642.0 | 2,534.9 | 2,815.6 |
| Total | 5,078.0 | 5,537.6 | 8,014.2 | 10,141.0 | 10,664.0 | 11,287.3 | 11,534.5 |
| **Total minerals and products** | | | | | | | |
| Crude material | 8,434.9 | 8,288.2 | 11,738.8 | 14,331.4 | 14,724.6 | 14,110.6 | 13,731.6 |
| Fabricated material | 4,724.1 | 6,456.8 | 8,095.8 | 11,368.7 | 11,362.3 | 9,685.2 | 10,876.6 |
| Total | 13,158.9 | 14,745.0 | 19,834.7 | 25,700.1 | 26,086.9 | 24,332.0 | 24,608.3 |

P Preliminary.

### TABLE 16. CANADA, VALUE OF IMPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, 1977-83

| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983P |
|---|---|---|---|---|---|---|---|
| | | | ($ million) | | | | |
| **Ferrous** | | | | | | | |
| Crude material | 106.0 | 223.8 | 322.1 | 354.2 | 373.2 | 227.5 | 285.2 |
| Fabricated material | 1,501.0 | 1,838.3 | 2,533.9 | 2,329.0 | 3,303.2 | 2,115.1 | 2,004.6 |
| Total | 1,607.0 | 2,062.1 | 2,856.0 | 2,683.2 | 3,676.4 | 2,342.5 | 2,289.8 |
| **Nonferrous** | | | | | | | |
| Crude material | 409.0 | 480.9 | 808.1 | 1,778.3 | 1,509.4 | 1,263.1 | 1,365.9 |
| Fabricated material | 662.1 | 949.1 | 2,122.7 | 2,784.6 | 2,433.4 | 1,862.4 | 2,358.7 |
| Total | 1,071.1 | 1,430.0 | 2,930.8 | 4,562.9 | 3,942.8 | 3,125.5 | 3,724.6 |
| **Nonmetals** | | | | | | | |
| Crude material | 170.6 | 231.0 | 284.5 | 329.3 | 339.3 | 282.2 | 271.9 |
| Fabricated material | 472.0 | 526.8 | 644.7 | 724.2 | 805.3 | 671.9 | 746.3 |
| Total | 642.6 | 757.8 | 929.2 | 1,053.5 | 1,144.6 | 954.1 | 1,018.2 |
| **Mineral fuels** | | | | | | | |
| Crude material | 3,876.4 | 4,092.8 | 5,364.3 | 7,732.3 | 8,696.9 | 5,906.3 | 4,115.8 |
| Fabricated material | 299.7 | 344.8 | 394.0 | 687.7 | 881.3 | 863.6 | 1,046.4 |
| Total | 4,176.1 | 4,437.6 | 5,758.3 | 8,420.0 | 9,578.2 | 6,769.9 | 5,162.3 |
| **Total minerals and products** | | | | | | | |
| Crude material | 4,562.0 | 5,028.6 | 6,779.0 | 10,194.1 | 10,918.7 | 7,679.0 | 6,038.8 |
| Fabricated material | 2,934.8 | 3,659.0 | 5,695.3 | 6,525.4 | 7,423.3 | 5,513.1 | 6,156.0 |
| Total | 7,496.8 | 8,687.6 | 12,474.3 | 16,719.5 | 18,342.0 | 13,192.1 | 12,194.8 |

P Preliminary.

### TABLE 17. CANADA, VALUE OF EXPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS IN RELATION TO TOTAL EXPORT TRADE, 1973, 1978 AND 1983

| | 1973 | | 1978 | | 1983P | |
|---|---|---|---|---|---|---|
| | ($ million) | (%) | ($ million) | (%) | ($ million) | (%) |
| Crude material | 4,593.4 | 18.4 | 8,288.2 | 11.1 | 13,731.6 | 15.5 |
| Fabricated material | 2,974.3 | 11.9 | 6,456.8 | 8.7 | 10,876.6 | 12.3 |
| Total | 7,567.7 | 30.4 | 14,745.0 | 19.8 | 24,608.3 | 27.8 |
| Total exports, all products | 24,837.9 | 100.0 | 74,259.3 | 100.0 | 88,506.2 | 100.0 |

P Preliminary.

### TABLE 18. CANADA, VALUE OF IMPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS IN RELATION TO TOTAL IMPORT TRADE. 1973, 1978 AND 1983

| | 1973 | | 1978 | | 1983P | |
|---|---|---|---|---|---|---|
| | ($ million) | (%) | ($ million) | (%) | ($ million) | (%) |
| Crude material | 1,535.5 | 6.6 | 5,028.6 | 10.0 | 6,038.8 | 8.0 |
| Fabricated material | 1,953.7 | 8.4 | 3,659.0 | 7.3 | 6,156.0 | 8.1 |
| Total | 3,489.2 | 15.0 | 8,687.6 | 17.3 | 12,194.8 | 16.1 |
| Total imports, all products | 23,325.3 | 100.0 | 50,107.7 | 100.0 | 75,586.6 | 100.0 |

P Preliminary.

### TABLE 19. CANADA, VALUE OF EXPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, BY MAIN GROUPS AND DESTINATION, 1983P

| | United States | United Kingdom | EFTA[1] | EEC[2] | Japan | Other Countries | Total |
|---|---|---|---|---|---|---|---|
| | | | | ($ million) | | | |
| Ferrous materials and products | 2,225.4 | 239.6 | 12.5 | 273.1 | 105.4 | 210.0 | 3,065.9 |
| Nonferrous materials and products | 4,496.2 | 462.5 | 232.9 | 708.1 | 738.6 | 832.2 | 7,470.5 |
| Nonmetallic mineral materials and products | 1,147.0 | 38.9 | 42.6 | 229.6 | 142.0 | 928.2 | 2,528.3 |
| Mineral fuels, materials and products | 10,170.9 | 0.9 | 15.2 | 94.6 | 949.5 | 312.4 | 11,534.5 |
| Total | 18,039.5 | 741.8 | 303.3 | 1,305.4 | 1,935.5 | 2,282.8 | 24,608.3 |
| Percentage of total mineral exports | 73.3 | 3.0 | 1.2 | 5.3 | 7.9 | 9.3 | 100.0 |

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[1] European Free Trade Association includes Austria, Norway, Portugal, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Greece, Denmark and Ireland.
P Preliminary.

### TABLE 20. CANADA, VALUE OF IMPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, BY MAIN GROUPS AND ORIGIN, 1983P

| | United States | United Kingdom | EFTA[1] | EEC[2] | Japan | Other Countries | Total |
|---|---|---|---|---|---|---|---|
| | | | | ($ million) | | | |
| Ferrous materials and products | 1,591.3 | 87.9 | 58.8 | 214.9 | 181.1 | 155.8 | 2,289.8 |
| Nonferrous materials and products | 2,552.4 | 45.9 | 138.8 | 168.4 | 77.3 | 741.6 | 3,724.6 |
| Nonmetallic mineral materials and products | 710.5 | 19.5 | 13.8 | 155.2 | 30.4 | 88.9 | 1,018.2 |
| Mineral fuels, materials and products | 1,930.0 | 209.7 | 53.8 | 52.9 | 0.2 | 2,915.7 | 5,162.3 |
| Total | 6,784.3 | 363.1 | 265.1 | 591.4 | 289.0 | 3,901.9 | 12,194.8 |
| Percentage of total mineral imports | 55.6 | 3.0 | 2.1 | 4.9 | 2.4 | 32.0 | 100.0 |

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[1] European Free Trade Association includes Austria, Norway, Portugal, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Greece, Denmark and Ireland.
P Preliminary.

TABLE 21. CANADA, VALUE OF EXPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, BY COMMODITY AND DESTINATION, 1983P

| | United States | United Kingdom | EFTA[1] | EEC[2] | Japan | Other Countries | Total |
|---|---|---|---|---|---|---|---|
| | | | | ($000) | | | |
| Aluminum | 1,278,351 | 6,043 | 7,742 | 31,934 | 229,323 | 306,831 | 1,860,224 |
| Asbestos | 87,642 | 25,590 | 17,949 | 93,177 | 42,008 | 217,088 | 483,454 |
| Copper | 360,957 | 96,722 | 43,946 | 171,857 | 277,865 | 234,052 | 1,185,399 |
| Fuels | 10,170,877 | 860 | 15,238 | 94,591 | 949,525 | 312,435 | 11,543,526 |
| Iron Ore | 479,970 | 226,770 | 8,780 | 212,577 | 83,124 | 43,109 | 1,054,330 |
| Lead | 46,212 | 13,827 | 2,473 | 28,032 | 1,752 | 10,771 | 103,067 |
| Molybdenum | 3,584 | 24,374 | 3,098 | 58,243 | 14,940 | 3,538 | 107,777 |
| Nickel | 364,010 | 124,499 | 146,899 | 113,416 | 37,600 | 46,733 | 833,157 |
| Primary ferrous metals | 219,208 | 540 | 20 | 41,267 | 19,462 | 16,248 | 296,745 |
| Uranium | 25,400 | 37,175 | - | - | - | - | 62,575 |
| Zinc | 349,662 | 32,917 | 9,999 | 216,378 | 24,023 | 149,586 | 782,565 |
| All other minerals | 4,653,647 | 152,482 | 47,130 | 243,924 | 255,836 | 942,416 | 6,295,435 |
| Total | 18,039,520 | 741,799 | 303,274 | 1,305,396 | 1,935,458 | 2,282,807 | 24,608,254 |

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[1] European Free Trade Association includes Austria, Norway, Portugal, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Greece, Denmark and Ireland.

P Preliminary; - Nil.

TABLE 22. CANADA, PHYSICAL VOLUME OF IMPORT TRADE FOR SELECTED COMMODITIES, 1977-83

| | Units of Weight | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983P |
|---|---|---|---|---|---|---|---|---|
| **Crude materials** | | | | | | | | |
| Metals | | | | | | | | |
| Alumina | t | 821 596 | 1 056 190 | 952 584 | 983 972 | 1 020 550 | 939 267 | 1 063 181 |
| Bauxite ore | t | 2 764 286 | 2 434 435 | 2 149 636 | 3 504 368 | 2 734 665 | 2 574 718 | 2 329 910 |
| Iron ore | t | 2 505 203 | 4 685 868 | 5 912 581 | 5 875 292 | 5 794 634 | 3 359 303 | 4 013 109 |
| Manganese ore | t | 57 644 | 136 446 | 45 150 | 95 161 | 119 746 | 71 656 | 42 260 |
| Nonmetals | | | | | | | | |
| Bentonite | t | 358 724 | 353 790 | 638 307 | 471 684 | 311 250 | 238 069 | 187 221 |
| Clay, ground & unground | t | 334 431 | 381 486 | 445 231 | 403 282 | 413 040 | 345 382 | 369 019 |
| Fluorspar | t | 124 494 | 170 237 | 167 904 | 223 940 | 173 599 | 126 954 | 141 928 |
| Limestone, crushed | t | 2 922 684 | 2 873 601 | 3 215 717 | 2 418 330 | 2 526 876 | 1 485 428 | 1 799 861 |
| Phosphate rock | t | 2 439 021 | 3 043 899 | 3 341 039 | 3 816 514 | 3 245 446 | 2 511 723 | 2 662 725 |
| Salt & brine | t | 1 126 225 | 1 330 474 | 1 275 627 | 1 151 203 | 1 254 992 | 1 526 881 | 814 254 |
| Sand & gravel | t | 1 645 663 | 1 810 989 | 1 201 915 | 1 209 582 | 1 446 872 | 1 179 285 | 878 614 |
| Silica sand | t | 1 101 186 | 1 242 444 | 1 651 890 | 1 200 237 | 1 142 880 | 788 768 | 982 662 |
| Fuels | | | | | | | | |
| Coal | t | 15 026 358 | 13 000 320 | 17 381 794 | 15 719 025 | 14 687 279 | 15 488 113 | 14 509 685 |
| Petroleum, crude | $m^3$ | 38 042 718 | 36 754 037 | 35 330 535 | 32 710 030 | 30 752 166 | 19 671 109 | 14 412 728 |
| **Fabricated materials** | | | | | | | | |
| Metals | | | | | | | | |
| Aluminum & aluminum alloy | t | 118 216 | 119 154 | 168 125 | 128 150 | 139 385 | 131 322 | 152 591 |
| Ferroalloys | t | 93 672 | 101 160 | 167 232 | 118 516 | 117 907 | 64 662 | 71 577 |
| Steel: | | | | | | | | |
| bars & rods | t | 301 502 | 318 336 | 300 069 | 189 853 | 340 772 | 219 638 | 278 151 |
| castings & forgings | t | 113 365 | 116 473 | 139 095 | 129 363 | 118 473 | 70 150 | 92 432 |
| pipes & tubes | t | 203 238 | 317 031 | 285 144 | 322 121 | 364 865 | 249 581 | 217 425 |
| sheets & strips | t | 552 606 | 704 502 | 1 039 054 | 582 233 | 1 717 134 | 540 390 | 535 546 |
| structural shapes | t | 225 869 | 151 502 | 273 111 | 207 657 | 362 891 | 120 360 | 162 231 |
| Nonmetals | | | | | | | | |
| Cement | t | 263 528 | 256 721 | 248 422 | 223 247 | 721 205 | 231 829 | 253 015 |
| Fire bricks | t | 242 720 | 156 002 | 227 156 | 236 205 | 187 016 | 132 600 | 154 795 |
| Phosphate fertilizers | t | 200 445 | 286 744 | 381 887 | 248 328 | 307 215 | 249 828 | 360 304 |
| Fuels | | | | | | | | |
| Coke | t | 1 267 895 | 1 527 342 | 1 366 182 | 1 311 535 | 1 436 074 | 1 064 536 | 1 345 806 |
| Fuel oil | 000 l | 1 260 034 | 1 277 077 | 871 425 | 1 617 606 | 1 256 790 | 1 571 003 | 1 468 464 |

P Preliminary.

TABLE 23. CANADA, PHYSICAL VOLUME OF EXPORT TRADE FOR SELECTED COMMODITIES, 1977-83

| | Unit of Weight | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983P |
|---|---|---|---|---|---|---|---|---|
| **Crude material** | | | | | | | | |
| Metals | | | | | | | | |
| Copper, ores & concentrates | t | 279 582 | 282 159 | 315 211 | 286 076 | 276 810 | 257 930 | 313 796 |
| Iron, ores | t | 45 060 391 | 31 929 094 | 48 849 270 | 39 020 922 | 41 452 044 | 27 281 396 | 25 527 960 |
| Lead, ores & concentrates | t | 137 820 | 142 693 | 151 485 | 147 008 | 146 304 | 106 744 | 85 460 |
| Zinc, ores & concentrates | t | 598 451 | 688 186 | 598 279 | 435 831 | 516 210 | 457 751 | 660 790 |
| Nonmetals | | | | | | | | |
| Asbestos, crude & fibers | t | 1 415 482 | 1 398 081 | 1 461 042 | 1 217 737 | 1 062 189 | 880 696 | 753 912 |
| Crude refractory materials | t | 747 938 | 1 081 684 | 1 023 734 | 803 892 | 629 770 | 40 839 | 241 131 |
| Gypsum | t | 4 994 323 | 5 178 631 | 5 474 764 | 4 960 240 | 5 094 873 | 4 775 780 | 5 187 032 |
| Limestone, crushed | t | 1 502 492 | 1 710 348 | 2 296 295 | 2 214 489 | 1 758 299 | 1 517 499 | 1 390 795 |
| Nepheline syenite | t | 443 763 | 420 961 | 471 056 | 448 468 | 476 281 | 414 787 | 398 299 |
| Salt and brine | t | 1 163 163 | 1 608 582 | 1 822 120 | 1 655 768 | 1 507 710 | 1 721 892 | 1 914 629 |
| Sand and gravel | t | 273 745 | 269 216 | 323 639 | 383 533 | 318 635 | 168 692 | 95 632 |
| Sulphur, crude | t | 4 291 032 | 4 984 545 | 5 154 831 | 6 850 143 | 7 309 216 | 6 111 444 | 5 670 275 |
| Fuels | | | | | | | | |
| Coal | t | 12 068 905 | 13 657 514 | 13 852 848 | 14 310 782 | 16 285 102 | 15 528 541 | 16 978 451 |
| Natural gas | 000 $m^3$ | 28 141 415 | 24 992 242 | 28 047 648 | 22 963 134 | 21 687 359 | 22 072 136 | 20 023 253 |
| **Fabricated materials** | | | | | | | | |
| Metals | | | | | | | | |
| Aluminum, pig ingots | t | 655 353 | 863 320 | 551 957 | 784 720 | 725 441 | 896 365 | 925 403 |
| Copper, refinery shapes | t | 294 490 | 247 727 | 191 211 | 335 200 | 263 046 | 232 623 | 298 528 |
| Iron, pig ingots | t | 505 277 | 544 716 | 255 523 | 562 351 | 466 360 | 485 620 | 348 278 |
| Lead, pig ingots | t | 130 819 | 131 950 | 117 992 | 126 538 | 119 815 | 146 126 | 147 265 |
| Zinc, pig ingots | t | 295 358 | 439 260 | 429 352 | 472 148 | 453 526 | 470 390 | 500 443 |
| Nonmetals | | | | | | | | |
| Cement | t | 1 274 652 | 1 634 582 | 2 288 822 | 1 550 562 | 1 578 659 | 1 752 129 | 1 561 080 |
| Lime, quick & hydrated | t | 359 540 | 478 551 | 490 863 | 403 166 | 432 845 | 281 247 | 215 942 |
| Peat | t | 303 414 | 312 903 | 358 267 | 390 457 | 326 826 | 326 826 | 396 884 |
| Fuels | | | | | | | | |
| Butane gas, liquified | 000 1 | 2 432 188 | 2 208 682 | 2 926 459 | 2 563 406 | 3 137 545 | 3 572 545 | 3 011 710 |
| Coke | t | 355 919 | 352 358 | 354 016 | 470 496 | 392 664 | 234 690 | 110 929 |
| Fuel oil | 000 1 | 1 456 991 | 4 232 409 | 4 654 162 | 4 273 510 | 3 846 907 | 2 718 769 | 3 825 520 |
| Gasoline | 000 1 | 388 080 | 972 282 | 913 271 | 706 539 | 600 969 | 536 268 | 1 240 028 |
| Propane gas, liquified | 000 1 | 5 019 524 | 3 543 782 | 4 858 175 | 3 879 915 | 3 867 950 | 4 513 307 | 3 534 562 |

P Preliminary.

TABLE 24. CANADA, APPARENT CONSUMPTION[1] OF SOME MINERALS, AND RELATION TO PRODUCTION[2], 1981-83

|  | Unit of Measure | 1981 Apparent Consumption | 1981 Production | 1981 Consumption as % of production | 1982 Apparent Consumption | 1982 Production | 1982 Consumption as % of production | 1983P Apparent Consumption | 1983P Production | 1983P Consumption as % of production |
|---|---|---|---|---|---|---|---|---|---|---|
| Asbestos | t | 60 590 | 1 121 845 | 5.4 | - | 834 249 | - | 87 462 | 840 277 | 10.4 |
| Cement | t | 9 294 745 | 10 152 199 | 91.6 | 6 636 084 | 8 156 391 | 81.4 | 6 470 832 | 7 778 897 | 83.2 |
| Gypsum | t | 2 074 045 | 7 025 418 | 29.5 | 1 674 259 | 5 987 396 | 28.1 | 3 123 950 | 7 693 759 | 40.6 |
| Iron ore | t | 13 893 389 | 49 550 799 | 28.0 | 8 666 497 | 33 197 561 | 26.1 | 12 020 643 | 32 869 627 | 36.6 |
| Lime |  | 2 145 087 | 2 554 788 | 84.0 | 1 932 124 | 2 197 298 | 87.9 | 2 032 615 | 2 225 713 | 91.3 |
| Quartz silica | t | 3 262 119 | 2 238 333 | 145.7 | 2 447 231 | 1 703 059 | 143.7 | 2 900 722 | 1 988 086 | 145.9 |
| Salt | t | 6 986 743 | 7 239 461 | 96.5 | 7 749 081 | 7 940 331 | 97.6 | 7 441 894 | 8 542 269 | 87.1 |

[1] "Apparent consumption" is production, plus imports, less exports. [2] "Production" refers to producers' shipments.
P Preliminary; - Nil.

## TABLE 25. CANADA, REPORTED CONSUMPTION OF MINERALS AND RELATION TO PRODUCTION, 1980-82

| | Unit of Measure | 1980 | | | 1981 | | | 1982p | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Consumption | Production | Consumption as % of production | Consumption | Production | Consumption as % of production | Consumption | Production | Consumption as % of production |
| **Metals** | | | | | | | | | | |
| Aluminum | t | 329 400 | 1 068 197 | 30.8 | 336 989 | 1 115 691 | 30.2 | 237 534 | 1 064 795 | 25.7 |
| Antimony | kg | 336 105 | .. | .. | 209 829 | .. | .. | 161 034 | .. | .. |
| Bismuth | kg | 10 271 | 149 566 | 6.9 | 10 094 | 167 885 | 6.0 | 10 074 | 189 132 | 5.3 |
| Cadmium | kg | 61 011 | 1 033 097 | 5.9 | 34 092 | 833 708 | 4.1 | 33 818 | 886 055 | 3.8 |
| Chromium (chromite) | t | 27 900 | - | .. | 24 771 | - | .. | 15 330 | - | .. |
| Cobalt | kg | 105 225 | 2 118 154 | 5.0 | 101 334 | 2 080 395 | 4.9 | 86 389 | 1 274 484 | 6.8 |
| Copper[1] | t | 195 124 | 716 363 | 27.2 | 216 759 | 691 327 | 31.4 | 130 559 | 612 455 | 21.3 |
| Lead[2] | t | 130 988 | 251 627 | 52.1 | 137 265 | 268 556 | 51.1 | 116 432 | 272 187 | 42.8 |
| Magnesium | t | 5 412 | 9 252 | 58.5 | 6 387 | .. | .. | 5 005 | .. | .. |
| Manganese ore | t | 157 680 | - | .. | 288 908 | - | .. | 130 826 | - | .. |
| Mercury | kg | 36 326 | - | .. | 35 635 | - | .. | 38 746 | - | .. |
| Molybdenum (Mo content) | t | 1 055 | 11 889 | 8.9 | 1 315 | 12 850 | 10.2 | 681 | 13 961 | 4.9 |
| Nickel | t | 9 676 | 184 802 | 5.2 | 8 603 | 160 247 | 5.4 | 6 637 | 88 581 | 7.5 |
| Selenium | kg | 10 795 | 279 626 | 3.9 | 9 414 | 255 369 | 3.7 | 10 469 | 222 323 | 4.7 |
| Silver | kg | 265 938 | 1 069 635 | 24.9 | 292 130 | 1 129 394 | 25.9 | 180 459 | 1 313 630 | 13.7 |
| Tellurium | kg | .. | 15 011 | .. | .. | 31 145 | .. | .. | 18 423 | .. |
| Tin | t | 4 517 | 243 | 1 858.8 | 3 766 | 239 | 1 575.7 | 3 528 | 135 | 2 613.3 |
| Tungsten (W content) | kg | 290 479 | 4 006 647 | 7.2 | 401 447 | 2 515 165 | 16.0 | 507 606 | 3 029 730 | 16.8 |
| Zinc | t | 116 618 | 885 697 | 13.2 | 113 061 | 911 178 | 12.4 | 100 232 | 965 607 | 10.4 |
| **Nonmetals** | | | | | | | | | | |
| Barite | t | 138 829 | 94 317 | 147.2 | 94 027 | 78 154 | 120.3 | 24 359 | 23 552 | 103.4 |
| Feldspar | t | 4 051 | - | .. | 4 606 | - | .. | 2 790 | - | .. |
| Fluorspar | t | 65 492 | - | .. | 135 091 | - | .. | 252 859 | - | .. |
| Mica | kg | 2 576 | - | .. | 2 259 | - | .. | 1 745 | - | .. |
| Nepheline syenite | t | 84 873 | 599 699 | 14.2 | 97 734 | 587 565 | 16.6 | 102 609 | 550 480 | 18.6 |
| Phosphate rock | t | 3 546 636 | - | .. | 3 254 779 | - | .. | 2 581 671 | - | .. |
| Potash ($K_2O$) | t | .. | 7 201 217 | .. | .. | 6 548 701 | .. | .. | 5 308 532 | .. |
| Sodium sulphate | t | 223 222 | 480 666 | 46.4 | 216 298 | 535 214 | 40.4 | 195 061 | 547 208 | 35.6 |
| Sulphur | t | 808 618 | 7 655 723 | 10.6 | 847 230 | 8 017 885 | 10.6 | 1 082 248 | 6 945 183 | 15.6 |
| Talc, etc. | t | 42 217 | 91 848 | 46.0 | 38 984 | 82 715 | 47.1 | 38 633 | 70 523 | 54.8 |
| **Fuels** | | | | | | | | | | |
| Coal | 000t | 37 333 | 36 688 | 101.8 | 38 367 | 40 088 | 95.7 | 41 500 | 42 906 | 96.7 |
| Natural gas[3] | million $m^3$ | 43 255 | 87 108 | 49.7 | 42 886 | 73 824 | 58.1 | 46 143 | 69 288 | 66.6 |
| Crude oil[4] | 000 $m^3$ | 109 802 | 83 477 | 131.5 | 100 777 | 74 553 | 135.2 | 86 528 | 79 255 | 109.2 |

Note: Unless otherwise stated, consumption refers to reported consumption of refined metals or nonmetallic minerals by consumers. Production of metals, in most cases, refers to production in all forms, and includes the recoverable content of ores, concentrates, matte, etc., and metal content of primary products recoverable at domestic smelters and refineries. Production of nonmetals refers to producers' shipments. For fuels, production is equivalent to actual output less waste.

[1] Consumption defined as producers domestic shipments of refined metal. [2] Consumption includes primary and secondary refined metal. [3] Consumption defined as domestic sales. [4] Consumption defined as refinery receipts.

p Preliminary; - Nil; .. Not available or not applicable.

## TABLE 26. CANADA, DOMESTIC CONSUMPTION OF PRINCIPAL REFINED METALS IN RELATION TO REFINERY PRODUCTION[1], 1976-82

| | Unit of Measure | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982P |
|---|---|---|---|---|---|---|---|---|
| **Copper** | | | | | | | | |
| Domestic consumption[2] | t | 206 205 | 200 372 | 228 694 | 210 689 | 195 124 | 216 759 | 130 559 |
| Production | t | 510 469 | 508 767 | 446 278 | 397 263 | 505 238 | 476 655 | 298 290 |
| Consumption of production | % | 40.4 | 39.4 | 51.2 | 53.0 | 38.6 | 45.5 | 43.8 |
| **Zinc** | | | | | | | | |
| Domestic consumption[3] | t | 98 897 | 105 412 | 121 375 | 131 317 | 116 618 | 113 061 | 100 232 |
| Production | t | 472 316 | 494 938 | 495 243 | 580 449 | 591 565 | 618 650 | 511 870 |
| Consumption of production | % | 20.9 | 21.3 | 24.5 | 22.6 | 19.7 | 18.3 | 19.6 |
| **Lead** | | | | | | | | |
| Domestic consumption[3] | t | 107 654 | 106 962 | 100 762 | 126 464 | 130 988 | 137 245 | 116 432 |
| Production | t | 175 720 | 187 457 | 194 054 | 183 769 | 162 463 | 168 450 | 174 310 |
| Consumption of production | % | 61.3 | 57.1 | 51.9 | 68.8 | 80.6 | 81.5 | 66.8 |
| **Aluminum** | | | | | | | | |
| Domestic consumption[4] | t | 332 206 | 322 393 | 380 291 | 398 834 | 329 400 | 336 989 | 237 534 |
| Production | t | 628 049 | 973 524 | 1 048 469 | 860 287 | 1 068 197 | 1 115 691 | 1 064 795 |
| Consumption of production | % | 51.3 | 34.1 | 36.3 | 46.4 | 30.8 | 30.2 | 25.7 |

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[1] Production of refined metal from all sources, including metal derived from secondary materials at primary refineries. [2] Producers' domestic shipments of refined metal. [3] Consumption of primary and secondary refined metal, reported by consumers. [4] Consumption of primary refined metal, reported by consumers.
P Preliminary.

TABLE 27A. AVERAGE ANNUAL PRICES[1] OF SELECTED MINERALS, 1977-83[2]

| | Unit of Measure | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|---|---|---|---|
| Aluminum, major U.S. producer[3] | cents/lb | 51.339 | 53.075 | 59.395 | 69.566 | 57.274 | 44.966 | 65.342 |
| Antimony, New York dealer | $/lb | 1.237 | 1.145 | 1.407 | 1.508 | 1.355 | 1.072 | 0.913 |
| Asbestos, No. 4 cement fibre | Cdn $/st | 551.000 | 642.000 | 687.000 | 769.000 | 850.000 | 876.000 | 1,003.000 |
| Bismuth, U.S. producer | $/lb | 6.010 | 3.378 | 3.011 | 2.637 | 2.044 | 2.300 | 2.300 |
| Cadmium, U.S. producer | $/lb | 2.962 | 2.450 | 2.760 | 2.843 | 1.927 | 1.113 | 1.129 |
| Calcium, metal crowns | $/lb | 1.482 | 1.680 | 1.868 | 2.502 | 2.831 | 3.050 | 3.050 |
| Chrome, U.S. metal, 9% carbon | $/lb | 2.900 | 3.080 | 3.375 | 4.017 | 4.450 | 4.450 | 4.450 |
| Cobalt metal, shot/cathode/250 kg | $/lb | 5.633 | 12.246 | 24.583 | 25.000 | 21.429[7] | 12.500 | 12.500 |
| Columbium, pyrochlore | $/lb | n | 2.550 | 2.550 | 2.550 | 3.250 | 3.250 | 3.250 |
| Copper, electrolytic cathode | Cdn $/lb | 0.695 | 0.746 | 1.076 | 1.178 | 1.004 | 0.885 | 0.769 |
| Gold, London[4] | Cdn $/troy oz | 157.089 | 220.407 | 359.289 | 716.087 | 551.178 | 465.102 | 520.792 |
| Iridium, major producer | $/troy oz | 300.000 | 300.000 | 258.333 | 505.833 | 600.000 | 600.000 | 600.000 |
| Iron ore, taconite pellets | cents/ltu | 55.300 | 57.108 | 63.966 | 69.562 | 80.073 | 80.500 | 80.500 |
| Lead, producer | Cdn cents/lb | 31.420 | 36.820 | 59.920 | 49.350 | 44.520 | 32.887 | 26.770 |
| Manganese, U.S. metal, regular | cents/lb | 58.000 | 58.000 | 58.333 | 61.267 | 70.000 | 86.274 | 67.583 |
| Magnesium, U.S. primary ingot | cents/lb | 97.487 | 100.500 | 105.758 | 116.667 | 130.250 | 134.000 | 136.508 |
| Mercury, New York | $/flask (76 lb) | 135.710 | 153.322 | 281.096 | 389.447 | 413.885 | 370.934 | 322.505 |
| Molybdenum, climax concentrate | $/lb | 3.730 | 4.644 | 7.762 | 9.768 | 8.493 | 9.740 | .. |
| Nickel, major producer cathode | $/lb | 2.360 | 2.091 | 2.707 | 3.415 | 3.429 | 3.200 | 3.200 |
| Osmium, major producer | $/troy oz | 170.000 | 150.000 | 150.000 | 150.000 | 150.000 | 139.167 | 110.000 |
| Palladium, major producer | $/troy oz | 59.702 | 70.873 | 113.143 | 213.975 | 129.500 | 110.000 | 130.000 |
| Platinum, major producer | $/troy oz | 162.544 | 237.250 | 351.649 | 439.425 | 475.000 | 475.000 | 475.000 |
| Potash, $K_2O$, coarse major producer | cents/stu | 76.000 | 80.583 | 100.417 | 112.667 | 120.750 | 119.615 | 116.000 |
| Rhodium, major producer | $/troy oz | 441.667 | 516.667 | 737.500 | 764.583 | 639.583 | 600.000 | 600.000 |
| Ruthenium, major producer | $/troy oz | 60.000 | 60.000 | 45.750 | 45.000 | 45.000 | 45.000 | 45.000 |
| Selenium, major producer commercial | $/lb | 17.000 | 15.000 | 12.250 | 9.654 | .. | .. | .. |
| Silver, Handy & Harman, Toronto | Cdn $/troy oz | 4.920 | 6.171 | 12.974 | 24.099 | 12.617 | 9.831 | 14.154 |
| Sulphur, elemental, major producer[5] | Cdn $/lt | 15.678 | 17.913 | 25.665 | 30.740 | 59.323 | 66.923 | 58.663 |
| Tantalum, Tanco | $/lb | 17.750 | 26.479 | 60.014 | 97.604 | 100.830 | 48.958 | 45.000 |
| Tellurium, major producer, slab | $/lb | 17.416 | 20.000 | 20.000 | 19.500 | .. | .. | .. |
| Tin | Cdn $/lb | 5.779 | 7.265 | 8.898 | 10.008 | 8.893 | 8.144 | 8.103 |
| Titanium, ilmenite ore | $/lt | 55.000 | 53.229 | 51.083 | 55.000 | 68.021 | 70.000 | 70.000 |
| Tungsten, U.S. hydrogen red | $/lb | 14.065 | 13.900 | 13.900 | 13.900 | 13.900 | 13.350 | 13.100 |
| Uranium, $U_3O_8$[6] | Cdn $/lb | 42.311 | 48.081 | 50.004 | 51.927 | 42.311 | 44.234 | 38.500 |
| Vanadium, pentoxide metallurgical | $/lb | 2.750 | 2.900 | 3.050 | 3.050 | 3.250 | 3.350 | 3.350 |
| Zinc, special high grade | Cdn cents/lb | 35.530 | 34.757 | 43.717 | 44.050 | 54.240 | 49.167 | 52.632 |

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[1] Prices except for noted, are in United States currency. [2] Sources: Alberta Energy Resource Industries Monthly Statistics, Asbestos, Engineering and Mining Journal, Metals Week and Northern Miner. [3] Starting 1981, London Metal Exchange. [4] Average afternoon fixings of London bullion dealers, converted to Canadian dollar. [5] Starting 1980, North American deliveries. [6] From Energy Mines and Resources Canada publications on assessment of Canada's uranium supply and demand series EP 77-3 to EP 83-3. [7] Seven month average.
.. Not available; n Nominal.

## TABLE 278. CANADIAN AVERAGE ANNUAL PRICES OF SELECTED MINERALS, 1977-83[1]

| | Unit of Measure | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|---|---|---|---|
| Aluminum, major U.S. producer[2] | $/kg | 1.204 | 1.334 | 1.534 | 1.793 | 1.514 | 1.223 | 1.775 |
| Antimony, New York dealer | $/kg | 2.900 | 2.879 | 3.634 | 3.887 | 3.582 | 2.917 | 2.481 |
| Asbestos, No. 4 cement fibre | $/mt | 607.373 | 707.684 | 757.288 | 847.677 | 936.964 | 965.625 | 1,105.618 |
| Bismuth, U.S. producer | $/kg | 14.091 | 8.495 | 7.777 | 6.796 | 5.403 | 6.258 | 6.249 |
| Cadmium, U.S. producer | $/kg | 6.945 | 6.161 | 7.128 | 7.327 | 5.094 | 3.028 | 3.067 |
| Calcium, metal crowns | $/kg | 3.475 | 4.225 | 4.825 | 6.448 | 7.483 | 8.298 | 8.287 |
| Chrome, U.S. metal, 9% carbon | $/kg | 6.799 | 7.745 | 8.717 | 10.353 | 11.763 | 12.107 | 12.090 |
| Cobalt metal, shot/cathode/250 kg | $/kg | 13.207 | 30.795 | 63.492 | 64.430 | 56.610[6] | 34.009 | 33.961 |
| Columbium, pyrochlore | $/kg | n | 6.413 | 6.586 | 6.572 | 8.591 | 8.842 | 8.830 |
| Copper, electrolytic cathode | $/kg | 1.532 | 1.645 | 2.372 | 2.597 | 2.213 | 1.951 | 1.695 |
| Gold, London[3] | $/gm | 5.051 | 7.086 | 11.551 | 23.023 | 17.721 | 14.953 | 16.744 |
| Iridium, major producer | $/gm | 10.258 | 11.002 | 9.730 | 19.011 | 23.129 | 23.806 | 23.773 |
| Iron Ore, taconite pellets | $/kg | 57.883 | 64.086 | 73.754 | 80.034 | 94.490 | 97.776 | 97.638 |
| Lead, producer | ¢/kg | 69.269 | 81.174 | 132.101 | 108.798 | 98.150 | [illegible] | 59.018 |
| Manganese, U.S. metal, regular | $/kg | 1.360 | 1.459 | 1.507 | 1.682 | 1.850 | 2.347 | 1.836 |
| Magnesium, U.S. primary ingot | $/kg | 2.286 | 2.527 | 2.731 | 3.007 | 3.443 | 3.646 | 3.709 |
| Mercury, New York | $/kg | 3.316 | 5.073 | 9.553 | 13.206 | 14.395 | 13.279 | 11.529 |
| Molybdenum, climax concentrate | $/kg | 8.745 | 11.678 | 20.047 | 25.174 | 22.450 | 26.500 | .. |
| Nickel, major producer cathode | $/kg | 5.533 | 5.258 | 6.992 | 8.801 | 9.064 | 8.706 | 8.694 |
| Osmium, major producer | $/gm | 5.813 | 5.501 | 5.650 | 5.638 | 5.782 | 5.522 | 4.358 |
| Palladium, major producer | $/gm | 2.041 | 2.599 | 4.262 | 8.042 | 4.992 | 4.364 | 5.151 |
| Platinum, major producer | $/gm | 5.558 | 8.701 | 13.245 | 16.515 | 18.310 | 18.847 | 18.820 |
| Potash, $K_2O$, coarse major producer | $/mt | 53.454 | 60.793 | 87.445 | 87.110 | 95.754 | 97.632 | 94.547 |
| Rhodium, major producer | $/gm | 15.102 | 18.948 | 27.778 | 28.736 | 24.655 | 23.806 | 23.773 |
| Ruthenium, major producer | $/gm | 2.052 | 2.200 | 1.723 | 1.691 | 1.735 | 1.785 | 1.783 |
| Selenium, major producer commercial | $/kg | 39.858 | 37.721 | 31.639 | 24.880 | .. | .. | .. |
| Silver, Handy & Harman, Toronto | $/kg | 158.182 | 198.402 | 417.124 | 774.801 | 405.646 | 316.074 | 455.062 |
| Sulphur, elemental, major producer[4] | $/mt | 15.430 | 17.630 | 25.260 | 30.255 | 58.386 | 65.866 | 59.604 |
| Tantalum, Tanco | $/kg | 41.617 | 66.587 | 155.002 | 251.545 | 266.524 | 133.201 | 122.259 |
| Tellurium, major producer, slab | $/kg | 40.834 | 50.294 | 51.655 | 50.255 | .. | .. | .. |
| Tin | $/kg | 12.740 | 16.017 | 19.617 | 22.064 | 19.606 | 17.954 | 17.864 |
| Titanium, ilmenite ore | $/mt | 57.566 | 61.791 | 58.900 | 63.280 | 80.268 | 85.022 | 84.902 |
| Uranium, U[5] | $/kg | 110.000 | 125.000 | 130.000 | 135.000 | 110.000 | 115.000 | 100.000 |
| Vanadium, pentoxide metallurgical | $/kg | 6.448 | 7.293 | 7.877 | 7.861 | 8.591 | 9.114 | 9.102 |
| Zinc, special high grade | $/kg | 0.783 | 0.766 | 0.964 | 0.971 | 1.196 | 1.084 | 1.160 |

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[1] Sources: Alberta Energy Resource Industries Monthly Statistics, Asbestos, Engineering and Mining Journal, Metals Week and Northern Miner. [2] Starting 1981, London Metal Exchange. [3] Average afternoon fixings of London bullion dealers, converted to Canadian dollar., [4] Starting 1980, North American deliveries. [5] From Energy Mines and Resources Canada publications on assessment of Canada's uranium supply and demand series EP 77-3 to EP 83-3. [6] Seven month average.

.. Not available; n Nominal.

TABLE 28. CANADA, MINERAL PRODUCTS INDUSTRIES, SELLING PRICE INDEXES, 1977-83 (1971 = 100)

| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983P |
|---|---|---|---|---|---|---|---|
| **Iron and steel products industries** | | | | | | | |
| Agricultural implements industry | 177.6 | 188.7 | 206.0 | 224.9 | 260.2 | 293.1 | 310.9 |
| Hardware, tool and cutlery manufacturers | 162.6 | 179.1 | 207.3 | 238.4 | 268.2 | 296.0 | 308.2 |
| Heating equipment manufacturers | 156.5 | 169.8 | 188.0 | 213.2 | 236.5 | 267.7 | 280.4 |
| Primary metal industries | 190.5 | 207.7 | 258.8 | 308.3 | 312.6 | 310.7 | 320.5 |
| Iron and steel mills | 187.9 | 203.9 | 233.7 | 261.7 | 290.3 | 314.2 | 319.2 |
| Steel pipe and tube mills | 197.8 | 218.0 | 248.1 | 276.9 | 322.1 | 362.6 | 359.7 |
| Iron foundries | 189.6 | 200.1 | 223.3 | 243.2 | 261.8 | 268.9 | 272.3 |
| Wire and wire products manufacturers | 175.4 | 185.8 | 206.4 | 226.9 | 242.4 | 249.6 | 252.7 |
| **Nonferrous metal products industries** | | | | | | | |
| Aluminum rolling, casting and extruding | 173.6 | 191.5 | 234.0 | 271.0 | 292.6 | 290.9 | 291.7 |
| Copper and alloy, rolling, casting and extruding | 144.5 | 153.0 | 201.8 | 219.7 | 205.8 | 193.0 | 206.4 |
| Jewellery and silverware manufacturers | 277.8 | 337.6 | 507.3 | 871.3 | 676.1 | 609.5 | 698.4 |
| Metal rolling, casting and extruding, nes | 216.3 | 239.8 | 310.4 | 327.3 | 325.7 | 314.0 | 324.3 |
| **Nonmetallic mineral products industries** | | | | | | | |
| Abrasives manufacturers | 194.7 | 223.6 | 255.3 | 290.6 | 325.1 | 361.8 | 371.0 |
| Cement manufacturers | 186.7 | 207.5 | 233.2 | 265.7 | 308.0 | 359.7 | 374.1 |
| Clay products and manufacturers from imported clay | 164.7 | 173.7 | 190.1 | 215.2 | 251.9 | 278.0 | 290.6 |
| Glass and glass products manufacturers | 150.4 | 162.1 | 173.4 | 197.0 | 223.2 | 250.2 | 259.3 |
| Lime manufacturers | 228.7 | 252.9 | 292.7 | 338.3 | 396.1 | 453.2 | 514.4 |
| Concrete products manufacturers | 173.7 | 187.7 | 200.1 | 222.5 | 259.4 | 296.7 | 310.5 |
| Clay products from domestic clay | 182.8 | 196.4 | 214.3 | 226.9 | 243.0 | 269.9 | 286.5 |
| Petroleum and coal products industries | 244.5 | 275.4 | 321.3 | 404.6 | 551.7 | 634.4 | 675.3 |
| Petroleum refineries | 246.7 | 278.7 | 325.8 | 410.6 | 559.8 | 643.7 | 685.2 |
| Mixed fertilizers | 180.2 | 191.0 | 229.0 | 280.3 | 289.5 | 294.6 | 284.1 |

nes Not elsewhere specified; P Preliminary.

## TABLE 29. CANADA, PRINCIPAL STATISTICS OF THE MINING INDUSTRY[1], 1982

| | Mining Activity | | | | | | | | Total Activity[2] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Production and Related Workers | | | Costs | | | | | | |
| | Establishments | Employees | Man-hours paid | Wages | Fuel and Electricity | Materials and Supplies | Value of Production | Value Added | Employees | Salaries and Wages | Value Added |
| | (number) | (number) | (000) | ($000) | ($000) | ($000) | ($000) | ($000) | (number) | ($000) | ($000) |
| **Metals** | | | | | | | | | | | |
| Gold quartz | 38 | 5,809 | 11,992 | 163,619 | 40,132 | 178,743 | 781,306 | 564,798 | 7,350 | 213,191 | 566,201 |
| Silver-lead-zinc | 22 | 4,812 | 10,260 | 153,782 | 62,993 | 538,067 | 963,324 | 362,264 | 6,837 | 226,671 | 351,126 |
| Nickel-copper-gold-silver | 40 | 21,365 | 35,134 | 495,302 | 186,426 | 1,287,897 | 2,599,607 | 1,125,284 | 28,851 | 742,653 | 1,144,859 |
| Iron | 12 | 6,578 | 11,843 | 181,650 | 154,237 | 432,317 | 1,377,020 | 790,466 | 10,676 | 320,149 | 761,429 |
| Uranium | 8 | 4,401 | 8,775 | 149,445 | 48,364 | 179,178 | 822,971 | 595,429 | 6,035 | 208,706 | 600,120 |
| Misc. metal mines | 7 | 1,296 | 2,367 | 36,687 | 15,789 | 61,968 | 146,622 | 68,864 | 1,754 | 54,365 | 73,705 |
| Total | 128 | 44,261 | 80,370 | 1,180,485 | 507,942 | 2,678,170 | 6,693,217 | 3,507,105 | 61,503 | 1,765,734 | 3,497,440 |
| **Nonmetals** | | | | | | | | | | | |
| Asbestos | 8 | 3,938 | 7,677 | 100,077 | 48,213 | 57,898 | 367,465 | 261,354 | 4,973 | 132,613 | 267,342 |
| Gypsum | 10 | 508 | 1,071 | 8,944 | 3,773 | 13,967 | 44,458 | 26,718 | 614 | 11,392 | 26,609 |
| Peat | 54 | 1,073 | 2,135 | 15,814 | 3,594 | 13,619 | 58,445 | 41,232 | 1,323 | 21,170 | 41,099 |
| Potash | 9 | 2,924 | 5,810 | 80,737 | 77,935 | 79,170 | 645,638 | 488,532 | 4,076 | 125,705 | 488,513 |
| Sand and gravel | 98 | 981 | 2,173 | 21,867 | 12,588 | 22,760 | 105,712 | 70,362 | 1,463 | 31,462 | 75,639 |
| Stone | 115 | 1,541 | 3,402 | 35,198 | 18,181 | 45,311 | 169,031 | 105,540 | 2,028 | 46,985 | 109,358 |
| Misc. nonmetals | 40 | 1,883 | 4,080 | 47,099 | 36,675 | 43,474 | 263,893 | 183,743 | 2,694 | 69,525 | 183,516 |
| Total | 334 | 12,848 | 26,348 | 309,736 | 200,959 | 276,199 | 1,654,642 | 1,177,481 | 17,171 | 438,852 | 1,192,076 |
| **Fuels** | | | | | | | | | | | |
| Coal | 30 | 10,281 | 20,268 | 292,976 | 94,129 | 296,456 | 1,232,968 | 842,383 | 13,113 | 393,582 | 838,012 |
| Oil, crude and natural gas | 756 | 7,568 | 15,639 | 242,697 | 153,266 | 517,946 | 19,520,791 | 18,849,579 | 31,699 | 1,049,836 | 18,915,469 |
| Total | 786 | 17,849 | 35,907 | 535,673 | 247,395 | 814,402 | 20,753,759 | 19,691,962 | 44,812 | 1,443,410 | 19,753,481 |
| Total mining industry | 1,248 | 74,958 | 142,625 | 2,025,894 | 956,296 | 3,768,771 | 29,101,618 | 24,376,548 | 123,486 | 3,648,004 | 24,442,997 |

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[1] Cement manufacturing, lime manufacturers, clay and clay products (domestic clays) are included in the mineral manufacturing industry. Industry coverage is the same as in Tables 31, 33, 35 and 37. [2] Total activity includes sales and head offices.

TABLE 30. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRIES[1], 1982

|  | Mineral Manufacturing Activity |  |  |  |  |  |  |  | Total Activity[2] |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Production and Related Workers |  |  | Costs |  |  |  |  |  |  |
|  | Establishments | Employees | Man-hours paid | Wages | Fuel and Electricity | Materials and Supplies | Value of Production | Value Added | Employees | Salaries and Wages | Value Added |
|  | (number) | (number) | (000) | ($000) | ($000) | ($000) | ($000) | ($000) | (number) | ($000) | ($000) |
| **Primary metal industries** |  |  |  |  |  |  |  |  |  |  |  |
| Iron and steel mills | 53 | 38,692 | 79,264 | 1,060,835 | 420,627 | 3,166,203 | 5,714,870 | 2,145,189 | 52,330 | 1,512,490 | 2,149,877 |
| Steel pipe and tube mills | 41 | 4,829 | 10,266 | 125,390 | 27,148 | 668,996 | 1,015,833 | 316,557 | 6,017 | 158,723 | 320,270 |
| Iron foundries | 114 | 6,587 | 13,030 | 137,059 | 35,185 | 224,899 | 518,849 | 280,198 | 8,163 | 181,159 | 279,984 |
| Smelting and refining | 33 | 21,986 | 45,298 | 620,008 | 329,218 | 1,512,489 | 3,369,309 | 1,389,160 | 33,215 | 1,003,852 | 1,492,967 |
| Aluminum rolling, casting and extruding | 73 | 4,435 | 9,480 | 100,224 | 30,442 | 581,770 | 899,339 | 290,484 | 6,255 | 154,649 | 289,900 |
| Copper and alloy rolling, casting and extruding | 38 | 2,036 | 3,992 | 44,223 | 11,235 | 278,421 | 399,500 | 108,211 | 2,541 | 57,955 | 101,632 |
| Metal rolling, casting and extruding, nes | 94 | 3,621 | 7,437 | 69,447 | 17,832 | 291,407 | 484,678 | 164,489 | 4,694 | 99,205 | 169,162 |
| Total | 446 | 82,186 | 168,768 | 2,157,186 | 871,687 | 6,724,186 | 12,402,450 | 4,690,917 | 113,215 | 3,168,033 | 4,803,751 |
| **Nonmetallic mineral products industries** |  |  |  |  |  |  |  |  |  |  |  |
| Cement manufacturers | 25 | 2,623 | 5,612 | 78,074 | 141,560 | 122,846 | 640,176 | 379,811 | 4,317 | 130,038 | 387,358 |
| Lime manufacturers | 15 | 653 | 1,408 | 17,290 | 44,328 | 18,421 | 122,352 | 59,770 | 895 | 24,622 | 60,126 |
| Concrete products manufacturers | 447 | 6,123 | 12,524 | 131,809 | 23,404 | 233,445 | 609,077 | 344,428 | 6,245 | 188,175 | 349,738 |
| Ready-mix concrete manufacturers | 530 | 6,061 | 12,609 | 147,927 | 45,074 | 575,697 | 991,888 | 368,475 | 8,034 | 199,972 | 388,623 |
| Clay products manufacturers (domestic) | 67 | 1,200 | 2,569 | 22,375 | 19,690 | 17,448 | 94,386 | 56,740 | 1,630 | 35,220 | 57,078 |
| Clay products manufacturers (imported) | 53 | 1,091 | 2,104 | 17,986 | 4,583 | 19,999 | 63,374 | 36,888 | 1,374 | 25,380 | 57,898 |
| Refractories manufacturers | 21 | 730 | 1,463 | 15,059 | 5,040 | 54,735 | 113,136 | 53,319 | 1,367 | 31,844 | 61,823 |
| Stone products manufacturers | 124 | 1,012 | 2,082 | 17,563 | 2,383 | 30,107 | 71,853 | 39,733 | 1,217 | 21,986 | 39,461 |
| Glass manufacturers | 15 | 5,790 | 11,995 | 125,290 | 64,480 | 161,329 | 567,065 | 341,932 | 7,756 | 180,400 | 339,628 |
| Glass products manufacturers | 108 | 2,668 | 5,156 | 51,540 | 9,990 | 134,966 | 289,990 | 143,316 | 3,260 | 66,592 | 144,873 |
| Abrasive manufacturers | 29 | 1,572 | 3,300 | 31,454 | 25,741 | 83,131 | 183,386 | 78,403 | 2,170 | 48,381 | 80,359 |
| Other nonmetallic mineral products industries | 101 | 4,475 | 9,230 | 95,949 | 58,537 | 273,175 | 638,586 | 301,106 | 7,684 | 182,710 | 325,444 |
| Total | 1,535 | 33,997 | 70,052 | 751,915 | 444,809 | 1,725,280 | 4,385,269 | 2,203,922 | 47,949 | 1,135,320 | 2,272,405 |
| **Petroleum and coal products industries** |  |  |  |  |  |  |  |  |  |  |  |
| Petroleum refining industry | 41 | 7,453 | 16,316 | 247,274 | 213,349 | 19,079,135 | 21,369,959 | 2,119,257 | 20,155 | 734,016 | 2,108,423 |
| Manufacture of lubricating oils & greases | 22 | 454 | 998 | 10,460 | 2,188 | 169,848 | 198,815 | 26,821 | 775 | 19,697 | 31,679 |
| Other petroleum & coal products industries | 62 | 368 | 766 | 8,288 | 5,215 | 103,038 | 144,381 | 37,336 | 571 | 13,695 | 39,949 |
| Total | 125 | 8,121 | 18,080 | 266,022 | 220,751 | 19,352,020 | 21,709,154 | 2,183,414 | 21,501 | 767,407 | 2,180,051 |
| Total, mineral manufacturing industries | 2,106 | 124,304 | 256,900 | 3,175,123 | 1,537,247 | 27,801,486 | 38,496,873 | 9,078,253 | 182,665 | 5,070,760 | 9,256,207 |

[1] Industry coverage is the same as in Tables 32, 34, 36 and 38. [2] Includes sales and head offices.
nes Not elsewhere specified.

## TABLE 31. CANADA, PRINCIPAL STATISTICS OF THE MINERAL INDUSTRY[1] BY REGION, 1982

|  |  | Mines, Quarries and Oil Well Activity |  |  |  |  |  |  | Total Activity[2] |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Production and Related Workers |  |  | Costs |  |  |  |  |  |  |
|  | Establishments (number) | Employees (number) | Man-hours paid (000) | Wages ($000) | Fuel and Electricity ($000) | Materials and Supplies ($000) | Value of Production ($000) | Value Added ($000) | Employees (number) | Salaries and Wages ($000) | Value Added ($000) |
| Atlantic[3] | 99 | 10,431 | 20,205 | 250,977 | 107,513 | 512,284 | 1,337,576 | 717,776 | 12,444 | 316,117 | 720,984 |
| Quebec | 182 | 13,025 | 25,876 | 331,138 | 160,019 | 509,859 | 1,683,770 | 1,013,892 | 18,777 | 513,260 | 1,007,576 |
| Ontario | 159 | 21,372 | 35,838 | 504,606 | 146,530 | 899,110 | 2,613,502 | 1,567,864 | 29,448 | 766,007 | 1,597,661 |
| Prairies | 555 | 16,912 | 33,714 | 480,988 | 313,484 | 874,567 | 20,546,439 | 19,358,387 | 43,585 | 1,369,696 | 19,405,619 |
| British Columbia[4] | 192 | 10,546 | 20,904 | 336,496 | 181,255 | 711,450 | 2,392,784 | 1,500,079 | 15,184 | 515,537 | 1,498,407 |
| Yukon and Northwest Territories[5] | 61 | 2,672 | 6,089 | 121,686 | 47,495 | 261,501 | 527,547 | 218,550 | 4,048 | 167,387 | 212,750 |
| Canada | 1,248 | 74,958 | 142,625 | 2,025,894 | 956,296 | 3,768,771 | 29,101,618 | 24,376,548 | 123,486 | 3,648,004 | 24,442,997 |

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[1] Cement manufacturing, lime manufacturing, clay and clay products are included in the mineral manufacturing industry. Industry coverage is the same as in Tables 29, 33, 35 and 37. [2] Total activity includes sales and head offices. [3] Includes eastern Canada offshore. [4] Includes western Canada offshore. [5] Includes Arctic Islands and offshore.

TABLE 32. CANADA STATISTICS OF THE MINERAL MANUFACTURING INDUSTRY[1] BY REGION, 1982

| | Mineral Manufacturing Activity | | | | | | | | Total Activity[2] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Production and Related Workers | | | Costs | | | | | | |
| | Establishments | Employees | Man-hours paid | Wages | Fuel and Electricity | Materials and Supplies | Value of Production | Value Added | Employees | Salaries and Wages | Value Added |
| | (number) | (number) | (000) | ($000) | ($000) | ($000) | ($000) | ($000) | (number) | ($000) | ($000) |
| *Atlantic Provinces* | 129 | (3) | (3) | (3) | (3) | (3) | (3) | (3) | (3) | (3) | (3) |
| Quebec | 527 | 28,490 | 58,831 | 748,101 | 476,139 | 7,164,363 | 9,905,848 | 2,216,934 | 43,120 | 1,203,081 | 2,285,976 |
| Ontario | 847 | 68,716 | 141,202 | 1,714,080 | 704,654 | 11,515,881 | 16,781,029 | 4,581,394 | 101,401 | 2,808,298 | 4,588,152 |
| Prairie Provinces | 352 | (3) | (3) | (3) | (3) | (3) | (3) | (3) | (3) | (3) | (3) |
| British Columbia | 249 | 9,685 | 20,390 | 276,862 | 87,070 | 2,478,265 | 3,511,214 | 916,048 | 13,913 | 415,564 | 987,459 |
| Yukon and Northwest Territories | 2 | (3) | (3) | (3) | (3) | (3) | (3) | (3) | (3) | (3) | (3) |
| Canada | 2,106 | 124,304 | 256,900 | 3,175,123 | 1,537,247 | 27,801,486 | 38,496,873 | 9,078,253 | 182,665 | 5,070,760 | 9,256,207 |

[1] Industry coverage same as in Tables 30, 34, 36 and 38. [2] Includes sales and head offices. [3] Confidential, included in Canadian total.

## TABLE 33. CANADA, PRINCIPAL STATISTICS OF THE MINING INDUSTRY[1], 1976-82

| | Mineral Manufacturing Activity | | | | | | | | Total Activity[2] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Production and Related Workers | | | Costs | | | | | | |
| | Establishments (number) | Employees (number) | Man-hours paid (000) | Wages ($000) | Fuel and Electricity ($000) | Materials and Supplies ($000) | Value of Production ($000) | Value Added ($000) | Employees (number) | Salaries and Wages ($000) | Value Added ($000) |
| 1976 | 1,244 | 78,989 | 163,426 | 1,185,184 | 401,899 | 2,438,672 | 14,178,010 | 11,337,439 | 117,694 | 1,902,682 | 11,360,511 |
| 1977 | 1,232 | 79,902 | 167,884 | 1,342,508 | 473,202 | 2,715,468 | 16,400,460 | 13,211,792 | 119,061 | 2,137,523 | 13,246,689 |
| 1978 | 1,179 | 70,306 | 150,291 | 1,275,008 | 501,335 | 2,766,072 | 18,201,459 | 14,934,052 | 109,948 | 2,118,342 | 15,016,214 |
| 1979 | 1,150 | 72,580 | 152,560 | 1,493,773 | 600,448 | 3,252,991 | 23,546,742 | 19,693,303 | 115,245 | 2,492,715 | 19,899,635 |
| 1980 | 1,323 | 80,066 | 166,427 | 1,779,389 | 706,405 | 3,802,062 | 27,661,246 | 23,152,778 | 126,422 | 2,979,470 | 23,347,682 |
| 1981 | 1,361 | 81,136 | 167,308 | 2,053,761 | 888,554 | 4,266,634 | 28,460,030 | 23,304,775 | 129,251 | 3,439,945 | 23,346,991 |
| 1982 | 1,248 | 74,958 | 142,625 | 2,025,894 | 956,296 | 3,768,771 | 29,101,618 | 24,376,548 | 123,486 | 3,648,004 | 24,442,997 |

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[1] Cement manufacturing, lime manufacturers, clay and clay products (domestic clays) are included in the mineral manufacturing industries. Industry coverage is the same as in Tables 29, 31, 35 and 37. [2] Includes sales and head offices.

## TABLE 34. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRIES[1], 1976-82

| | Mineral Manufacturing Activity | | | | | | | | Total Activity[2] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Production and Related Workers | | | Costs | | | | | | |
| | Establishments (number) | Employees (number) | Man-hours paid (000) | Wages ($000) | Fuel and Electricity ($000) | Materials and Supplies ($000) | Value of Production ($000) | Value Added ($000) | Employees (number) | Salaries and Wages ($000) | Value Added ($000) |
| 1976 | 1,662 | 137,310 | 284,392 | 1,898,753 | 655,828 | 10,798,653 | 16,793,147 | 5,548,868 | 188,751 | 2,820,873 | 5,687,750 |
| 1977 | 1,616 | 138,700 | 288,409 | 2,110,400 | 798,486 | 12,743,217 | 19,725,082 | 6,489,111 | 189,576 | 3,114,744 | 6,594,794 |
| 1978 | 2,022 | 143,917 | 297,554 | 2,365,782 | 981,506 | 15,700,614 | 24,036,539 | 7,272,298 | 198,085 | 3,494,336 | 7,421,897 |
| 1979 | 2,115 | 145,929 | 308,770 | 2,614,816 | 1,118,146 | 19,116,369 | 28,318,690 | 8,522,128 | 202,695 | 3,910,454 | 8,569,240 |
| 1980 | 2,143 | 146,606 | 308,312 | 2,927,363 | 1,272,902 | 22,045,572 | 32,177,335 | 9,417,966 | 204,872 | 4,386,065 | 9,599,868 |
| 1981 | 2,124 | 140,914 | 293,781 | 3,187,784 | 1,560,453 | 28,125,138 | 39,495,229 | 10,862,006 | 203,051 | 4,932,893 | 11,062,937 |
| 1982 | 2,106 | 124,304 | 256,900 | 3,175,123 | 1,537,247 | 27,801,486 | 38,496,873 | 9,078,253 | 182,665 | 5,070,760 | 9,256,207 |

[1] Industry coverage is the same as in Tables 30, 32, 36 and 38. [2] Includes sales and head offices.

## TABLE 35. CANADA, CONSUMPTION OF FUEL AND ELECTRICITY IN THE MINING INDUSTRY[1], 1982

| | Unit | Metals | Nonmetals | Fuels | Total |
|---|---|---|---|---|---|
| Coal and coke | 000 t | 109 | 16 | - | 125 |
| | $000 | 4,778 | 408 | - | 5,186 |
| Gasoline | 000 litres | 23 445 | 15 562 | 14 851 | 53 868 |
| | $000 | 9,352 | 6,172 | 5,215 | 20,739 |
| Fuel oil, kerosene, diesel oil | 000 litres | 935 507 | 224 392 | 155 464 | 1 315 363 |
| | $000 | 221,129 | 63,044 | 48,729 | 332,902 |
| Liquefied petroleum gas | 000 litres | 102 395 | 6 000 | 7 910 | 116 205 |
| | $000 | 19,310 | 1,520 | 1,541 | 22,371 |
| Natural gas | 000 $m^3$ | 144 660 | 675 784 | 175 000 | 995 444 |
| | $000 | 19,503 | 70,531 | 14,200 | 104,234 |
| Other fuels[2] | $000 | 1,733 | 1,718 | 800 | 4,251 |
| Total value of fuels | $000 | 275,805 | 143,393 | 70,484 | 489,683 |
| Electricity purchased | million kWh | 9 891 | 1 782 | 5 780 | 17 453 |
| | $000 | 232,137 | 57,567 | 176,911 | 466,614 |
| Total value of fuels and electricity purchased, all reporting companies | $000 | 507,942 | 200,960 | 247,395 | 956,297 |

Note: Totals may not add due to rounding.

[1] Cement and lime manufacturing and manufacturers of clay products (domestic clays) are included under mineral manufacturing, Tables 36 and 38. Industry coverage is the same as in Tables 29, 31, 33 and 37. [2] Includes wood, manufactured gas, steam purchased and other miscellaneous fuels.

- Nil.

**TABLE 36. CANADA, CONSUMPTION OF FUEL AND ELECTRICITY IN THE MINERAL MANUFACTURING INDUSTRIES[1], 1982**

| | Unit | Primary Metal Industries | Nonmetallic Mineral Products Industries | Petroleum and Coal Products Industries | Total |
|---|---|---|---|---|---|
| Coal and coke | 000 t | 294 | 602 | - | 896 |
| | $000 | 36,019 | 36,127 | - | 72,146 |
| Gasoline | 000 litres | 15 530 | 26 761 | 4 416 | 46 707 |
| | $000 | 5,805 | 10,253 | 2,016 | 18,074 |
| Fuel oil, kerosene, diesel oil | 000 litres | 938 364 | 384 636 | 13 375 | 1 336 375 |
| | $000 | 175,912 | 86,077 | 3,656 | 265,645 |
| Liquefied petroleum gas | 000 litres | 48 180 | 19 430 | 3 184 | 70 794 |
| | $000 | 8,899 | 3,823 | 310 | 13,032 |
| Natural gas | 000 $m^3$ | 2 266 900 | 1 405 800 | 1 033 200 | 4 705 900 |
| | $000 | 292,061 | 173,877 | 122,797 | 588,735 |
| Other fuels | $000 | 7,377 | 18,409 | 5,524 | 31,310 |
| Total value of fuels | $000 | 526,073 | 328,566 | 134,303 | 988,942 |
| Electricity purchased | million kWh | 16 848 | 3 973 | 3 476 | 24 297 |
| | $000 | 345,614 | 116,243 | 86,448 | 548,305 |
| Total value of fuels and electricity purchased, all reporting companies | $000 | 871,687 | 444,809 | 220,751 | 1,537,247 |

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[1] Industry coverage is the same as in Tables 30, 32, 34 and 38.
- Nil.

## TABLE 37. CANADA, COST OF FUEL AND ELECTRICITY USED IN THE MINING INDUSTRY[1], 1976-82

| | Unit | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|---|
| **Metals** | | | | | | | | |
| Fuel | $000 | 128,637 | 148,578 | 153,608 | 193,828 | 220,052 | 293,979 | 275,205 |
| Electricity purchased | million kWh | 11 326 | 11 713 | 10 739 | 11 459 | 11 024 | 10 494 | 9 891 |
| | $000 | 107,318 | 135,014 | 132,100 | 153,905 | 174,837 | 209,316 | 232,137 |
| Total cost of fuel and electricity | $000 | 235,955 | 283,591 | 285,708 | 347,733 | 394,889 | 503,295 | 507,942 |
| **Nonmetals[2]** | | | | | | | | |
| Fuel | $000 | 62,453 | 72,946 | 79,090 | 92,499 | 112,672 | 142,169 | 143,393 |
| Electricity purchased | million kWh | 1 959 | 2 457 | 2 082 | 2 244 | 2 269 | 2 100 | 1 782 |
| | $000 | 23,401 | 29,510 | 35,141 | 42,982 | 48,336 | 56,297 | 57,567 |
| Total cost of fuel and electricity | $000 | 85,854 | 102,456 | 114,231 | 135,481 | 161,008 | 198,466 | 200,960 |
| **Fuels** | | | | | | | | |
| Fuels | $000 | 12,015 | 15,117 | 19,774 | 23,988 | 32,582 | 46,991 | 70,484 |
| Electricity purchased | million kWh | 2 770 | 2 791 | 2 699 | 3 238 | 3 504 | 3 740 | 5 780 |
| | $000 | 68,075 | 72,035 | 81,624 | 98,783 | 117,927 | 139,802 | 176,911 |
| Total cost of fuel and electricity | $000 | 80,090 | 87,152 | 101,398 | 122,771 | 150,509 | 186,793 | 247,395 |
| **Total mining industry** | | | | | | | | |
| Fuel | $000 | 203,105 | 236,642 | 252,470 | 310,315 | 365,306 | 483,139 | 489,683 |
| Electricity purchased | million kWh | 16 055 | 16 961 | 15 520 | 16 941 | 16 797 | 16 334 | 17 453 |
| | $000 | 198,794 | 236,559 | 248,865 | 295,670 | 341,100 | 405,415 | 466,614 |
| Total cost of fuel and electricity | $000 | 401,899 | 473,201 | 501,335 | 605,985 | 706,406 | 888,554 | 956,297 |

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[1] Cement and lime manufacturing and manufacture of clay products (domestic clays) are included in mineral manufacturing, Tables 36 and 38. Industry coverage is the same as in Tables 29, 31, 33 and 35. [2] Includes structural materials.

## TABLE 38. CANADA, COST OF FUEL AND ELECTRICITY USED IN THE MINERAL MANUFACTURING INDUSTRIES[1], 1976-82

| | Unit | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|---|
| **Primary metals** | | | | | | | | |
| Fuel | $000 | 224,928 | 279,172 | 336,684 | 357,775 | 421,426 | 538,175 | 526,073 |
| Electricity purchased | million kWh | 16 497 | 15 352 | 17 257 | 18 451 | 20 535 | 20 429 | 16 848 |
| | $000 | 151,011 | 183,574 | 226,313 | 260,317 | 316,884 | 357,186 | 345,614 |
| Total cost of fuel and electricity | $000 | 375,939 | 462,746 | 562,997 | 618,092 | 738,317 | 895,361 | 871,687 |
| **Nonmetallic mineral products** | | | | | | | | |
| Fuel | $000 | 162,312 | 181,952 | 221,855 | 280,846 | 271,481 | 333,061 | 328,566 |
| Electricity purchased | million kWh | 4 137 | 4 190 | 4 782 | 5 163 | 4 633 | 4 573 | 3 973 |
| | $000 | 52,113 | 65,553 | 79,606 | 98,296 | 102,765 | 114,062 | 116,243 |
| Total cost of fuel and electricity | $000 | 214,425 | 247,507 | 301,461 | 379,142 | 374,248 | 447,123 | 444,809 |
| **Petroleum and coal products** | | | | | | | | |
| Fuel | $000 | 30,474 | 42,184 | 61,891 | 74,968 | 88,311 | 137,463 | 134,303 |
| Electricity purchased | million kWh | 3 010 | 3 205 | 3 505 | 3 555 | 3 705 | 3 669 | 3 476 |
| | $000 | 34,988 | 46,050 | 55,303 | 63,395 | 72,186 | 80,517 | 86,448 |
| Total cost of fuel and electricity | $000 | 65,462 | 88,233 | 117,194 | 138,363 | 160,498 | 217,980 | 220,751 |
| **Total mineral manufacturing industries** | | | | | | | | |
| Fuel | $000 | 417,714 | 503,308 | 620,430 | 713,589 | 781,218 | 1,008,699 | 988,942 |
| Electricity purchased | million kWh | 23 644 | 22 747 | 25 544 | 27 169 | 28 873 | 28 671 | 24 297 |
| | $000 | 238,112 | 295,177 | 361,222 | 422,008 | 491,834 | 551,765 | 548,305 |
| Total cost of fuel and electricity | $000 | 655,826 | 798,486 | 981,652 | 1,135,597 | 1,273,063 | 1,560,464 | 1,537,247 |

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[1] Industry coverage is the same as in Tables 30, 32, 34 and 36.

TABLE 39. CANADA, EMPLOYMENT, SALARIES AND WAGES IN THE MINING INDUSTRY[1], 1976-82

| | Unit | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|---|
| **Metals** | | | | | | | | |
| Production and related workers | Number | 49,834 | 49,414 | 39,977 | 41,541 | 47,592 | 49,586 | 44,261 |
| Salaries and wages | $000 | 759,499 | 849,345 | 757,258 | 879,383 | 1,091,848 | 1,265,547 | 1,180,485 |
| Annual average salary and wage | $ | 15,241 | 17,188 | 18,942 | 21,169 | 22,942 | 25,522 | 26,671 |
| Administrative and office workers | Number | 18,435 | 17,831 | 16,470 | 17,419 | 18,526 | 19,126 | 17,242 |
| Salaries and wages | $000 | 352,867 | 377,714 | 358,680 | 428,639 | 504,316 | 585,120 | 585,249 |
| Annual average salary and wage | $ | 19,140 | 21,183 | 21,778 | 24,608 | 27,222 | 30,593 | 33,943 |
| Total metals | | | | | | | | |
| Employees | Number | 68,269 | 67,245 | 56,447 | 58,960 | 66,118 | 68,712 | 61,503 |
| Salaries and wages | $000 | 1,112,366 | 1,227,059 | 1,115,938 | 1,308,022 | 1,596,165 | 1,850,667 | 1,765,734 |
| Annual average salary and wage | $ | 16,298 | 18,248 | 19,770 | 22,185 | 24,141 | 26,933 | 28,710 |
| **Nonmetals** | | | | | | | | |
| Production and related workers | Number | 16,447 | 16,812 | 16,133 | 16,633 | 16,645 | 15,666 | 12,848 |
| Salaries and wages | $000 | 237,982 | 266,294 | 274,037 | 321,303 | 343,004 | 352,302 | 309,736 |
| Annual average salary and wage | $ | 14,470 | 15,840 | 16,986 | 19,317 | 20,607 | 22,488 | 24,108 |
| Administrative and office workers | Number | 4,887 | 4,986 | 4,749 | 4,829 | 4,795 | 4,908 | 4,323 |
| Salaries and wages | $000 | 82,861 | 89,757 | 95,659 | 106,776 | 116,932 | 128,852 | 129,116 |
| Annual average salary and wage | $ | 16,955 | 18,002 | 20,143 | 22,111 | 24,386 | 26,253 | 29,867 |
| Total nonmetals | | | | | | | | |
| Employees | Number | 21,334 | 21,798 | 20,882 | 21,462 | 21,440 | 20,574 | 17,171 |
| Salaries and wages | $000 | 320,843 | 356,051 | 369,696 | 428,079 | 459,936 | 481,154 | 438,852 |
| Annual average salary and wage | $ | 15,039 | 16,334 | 17,704 | 19,946 | 21,452 | 23,387 | 25,558 |
| **Fuels** | | | | | | | | |
| Production and related workers | Number | 12,708 | 13,679 | 14,196 | 14,406 | 15,829 | 15,884 | 17,849 |
| Salaries and wages | $000 | 187,704 | 226,869 | 243,713 | 293,087 | 344,537 | 435,911 | 535,673 |
| Annual average salary and wage | $ | 14,771 | 16,585 | 17,168 | 20,345 | 21,766 | 27,443 | 30,011 |
| Administrative and office workers | Number | 15,383 | 16,342 | 18,423 | 20,417 | 23,035 | 24,081 | 26,963 |
| Salaries and wages | $000 | 281,789 | 327,544 | 388,995 | 463,527 | 578,832 | 672,213 | 907,745 |
| Annual average salary and wage | $ | 18,318 | 20,043 | 21,115 | 22,703 | 25,128 | 27,915 | 33,666 |
| Total fuels | | | | | | | | |
| Employees | Number | 28,091 | 30,021 | 32,619 | 34,823 | 38,864 | 39,965 | 44,812 |
| Salaries and wages | $000 | 469,493 | 554,413 | 632,708 | 756,614 | 923,369 | 1,108,124 | 1,443,418 |
| Average annual salary and wage | $ | 16,713 | 18,468 | 19,397 | 21,727 | 23,759 | 27,727 | 32,211 |
| **Total mining** | | | | | | | | |
| Production and related workers | Number | 78,989 | 79,905 | 70,306 | 72,580 | 80,066 | 81,136 | 74,958 |
| Salaries and wages | $000 | 1,185,184 | 1,342,508 | 1,275,008 | 1,493,773 | 1,779,389 | 2,053,761 | 2,025,894 |
| Average annual salary and wage | $ | 15,004 | 16,801 | 18,135 | 20,581 | 22,224 | 25,313 | 27,027 |
| Administrative and office workers | Number | 38,705 | 39,159 | 39,642 | 42,665 | 46,356 | 48,115 | 48,528 |
| Salaries and wages | $000 | 717,498 | 795,015 | 843,335 | 998,942 | 1,200,081 | 1,386,184 | 1,622,110 |
| Annual average salary and wage | $ | 18,538 | 20,302 | 21,274 | 23,414 | 25,888 | 28,810 | 33,426 |
| Total mining | | | | | | | | |
| Employees | Number | 117,694 | 119,064 | 109,948 | 115,245 | 126,422 | 129,251 | 123,486 |
| Salaries and wages | $000 | 1,902,682 | 2,137,523 | 2,118,343 | 2,492,715 | 2,979,470 | 3,439,945 | 3,648,004 |
| Annual average salary and wage | $ | 16,166 | 17,954 | 19,267 | 21,630 | 23,568 | 26,614 | 29,542 |

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[1] Does not include cement and lime manufacturing and clay products (domestic clays) manufacturing. These industries are included in the following table under "Nonmetallic mineral products industries".

## TABLE 40. CANADA, EMPLOYMENT, SALARIES AND WAGES IN THE MINERAL MANUFACTURING INDUSTRIES, 1976-82

| | Unit | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|---|
| **Primary metal industries** | | | | | | | | |
| Production and related workers | Number | 88,939 | 91,683 | 93,798 | 95,942 | 97,530 | 92,337 | 82,186 |
| Salaries and wages | $000 | 1,241,893 | 1,399,390 | 1,544,412 | 1,725,904 | 1,980,423 | 2,120,019 | 2,157,186 |
| Annual average salary and wage | $ | 13,963 | 15,263 | 16,465 | 17,989 | 20,306 | 22,960 | 26,248 |
| Administrative and office workers | Number | 28,102 | 27,536 | 28,198 | 30,812 | 28,920 | 32,831 | 31,029 |
| Salaries and wages | $000 | 511,236 | 545,957 | 597,544 | 713,279 | 787,022 | 938,790 | 1,010,847 |
| Annual average salary and wage | $ | 18,192 | 19,827 | 21,191 | 23,149 | 27,214 | 28,595 | 32,577 |
| Total primary metal industries | | | | | | | | |
| Employees | Number | 117,041 | 119,219 | 121,996 | 126,754 | 126,450 | 125,168 | 113,215 |
| Salaries and wages | $000 | 1,753,128 | 1,945,347 | 2,140,956 | 2,432,183 | 2,767,445 | 3,058,809 | 3,168,033 |
| Annual average salary and wage | $ | 14,979 | 16,317 | 17,549 | 19,188 | 21,886 | 24,438 | 27,982 |
| **Nonmetallic mineral products industries** | | | | | | | | |
| Production and related workers | Number | 41,272 | 39,321 | 41,297 | 41,813 | 40,799 | 40,145 | 33,997 |
| Salaries and wages | $000 | 529,264 | 564,444 | 638,152 | 710,622 | 743,254 | 818,566 | 751,915 |
| Annual average salary and wage | $ | 12,824 | 14,355 | 15,452 | 16,995 | 18,217 | 20,390 | 22,117 |
| Administrative and office workers | Number | 13,749 | 13,187 | 14,439 | 14,935 | 15,287 | 15,124 | 13,952 |
| Salaries and wages | $000 | 218,164 | 229,855 | 264,166 | 297,211 | 333,815 | 369,899 | 383,405 |
| Annual average salary and wage | $ | 15,868 | 17,430 | 18,295 | 19,900 | 21,837 | 24,458 | 27,480 |
| Total nonmetallic mineral products | | | | | | | | |
| Employees | Number | 55,021 | 52,508 | 55,736 | 56,748 | 56,086 | 55,269 | 47,949 |
| Salaries and wages | $000 | 747,428 | 794,299 | 902,318 | 1,007,833 | 1,077,069 | 1,188,455 | 1,135,320 |
| Annual average salary and wage | $ | 13,584 | 15,127 | 16,189 | 17,760 | 19,203 | 21,503 | 23,678 |
| **Petroleum and coal products industries** | | | | | | | | |
| Production and related workers | Number | 7,099 | 7,696 | 8,822 | 8,174 | 8,277 | 8,432 | 8,121 |
| Salaries and wages | $000 | 127,594 | 146,566 | 183,218 | 185,290 | 203,686 | 249,199 | 266,022 |
| Annual average salary and wage | $ | 17,974 | 19,044 | 20,768 | 22,668 | 24,609 | 29,554 | 32,757 |
| Administrative and office workers | Number | 9,590 | 10,153 | 11,531 | 11,019 | 11,769 | 14,182 | 13,380 |
| Salaries and wages | $000 | 192,722 | 228,532 | 267,844 | 285,148 | 337,865 | 436,430 | 501,385 |
| Annual average salary and wage | $ | 20,096 | 22,509 | 23,228 | 25,887 | 28,708 | 30,773 | 37,473 |
| Total petroleum and coal products | | | | | | | | |
| Employees | Number | 16,689 | 17,849 | 20,353 | 19,193 | 20,046 | 22,614 | 21,501 |
| Salaries and wages | $000 | 320,316 | 375,098 | 451,062 | 470,438 | 541,551 | 685,629 | 767,407 |
| Annual average salary and wage | $ | 19,193 | 21,015 | 22,162 | 24,511 | 27,015 | 30,319 | 35,692 |
| **Total mineral manufacturing** | | | | | | | | |
| Production and related workers | Number | 137,310 | 138,700 | 143,917 | 145,929 | 146,606 | 140,914 | 124,304 |
| Salaries and wages | $000 | 1,898,751 | 2,110,400 | 2,365,782 | 2,621,816 | 2,927,363 | 3,187,784 | 3,175,123 |
| Annual average salary and wage | $ | 13,828 | 15,216 | 16,439 | 17,966 | 19,968 | 22,622 | 25,543 |
| Administrative and office workers | Number | 51,441 | 50,876 | 54,168 | 56,766 | 55,976 | 62,137 | 58,359 |
| Salaries and wages | $000 | 922,122 | 1,004,344 | 1,129,554 | 1,295,638 | 1,458,702 | 1,745,109 | 1,895,637 |
| Annual average salary and wage | $ | 17,926 | 19,741 | 20,853 | 22,824 | 26,059 | 28,085 | 32,482 |
| Total mineral manufacturing industries | | | | | | | | |
| Employees | Number | 188,751 | 189,576 | 198,085 | 202,695 | 202,582 | 203,051 | 182,663 |
| Salaries and wages | $000 | 2,820,872 | 3,114,744 | 3,494,336 | 3,910,454 | 4,386,065 | 4,932,893 | 5,070,760 |
| Annual average salary and wage | $ | 14,945 | 16,430 | 17,641 | 19,292 | 21,651 | 24,294 | 27,760 |

## TABLE 41. CANADA, NUMBER OF WAGE EARNERS EMPLOYED IN THE MINING INDUSTRY, (SURFACE, UNDERGROUND AND MILL), 1976-82

| | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|
| **Metals** | | | | | | | |
| Surface | 16,143 | 16,115 | 12,901 | 12,664 | 14,347 | 14,043 | 12,133 |
| Underground | 20,043 | 19,482 | 15,682 | 15,906 | 19,308 | 19,784 | 18,673 |
| Mill | 13,648 | 13,817 | 11,394 | 12,971 | 13,937 | 15,759 | 13,455 |
| Total | 49,834 | 49,414 | 39,977 | 41,541 | 47,592 | 49,586 | 44,261 |
| **Nonmetals** | | | | | | | |
| Surface | 7,264 | 7,166 | 6,660 | 6,877 | 6,510 | 6,015 | 4,833 |
| Underground | 2,180 | 2,245 | 2,275 | 2,370 | 2,550 | 2,606 | 2,055 |
| Mill | 7,003 | 7,401 | 7,198 | 7,386 | 7,585 | 7,045 | 5,960 |
| Total | 16,447 | 16,812 | 16,133 | 16,633 | 16,645 | 15,666 | 12,848 |
| **Fuels** | | | | | | | |
| Surface | 9,705 | 10,510 | 11,045 | 11,535 | 12,929 | 12,958 | 14,623 |
| Underground | 3,003 | 3,169 | 3,151 | 2,871 | 2,900 | 2,926 | 3,226 |
| Total | 12,708 | 13,679 | 14,196 | 14,406 | 15,829 | 15,884 | 17,849 |
| **Total mining industry** | | | | | | | |
| Surface | 33,112 | 33,791 | 30,606 | 31,076 | 33,786 | 33,016 | 31,589 |
| Underground | 25,226 | 24,896 | 21,108 | 21,147 | 24,758 | 25,316 | 23,954 |
| Mill | 20,651 | 21,218 | 18,592 | 20,357 | 21,522 | 22,804 | 19,415 |
| Total | 78,989 | 79,905 | 70,306 | 72,580 | 80,066 | 81,136 | 74,958 |

## TABLE 42. CANADA, MINE AND MILL WORKERS BY SEX, 1982

| | Mine workers | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Underground | | Surface | | Mill workers | | Total | |
| | Male | Female | Male | Female | Male | Female | Male | Female |
| **Metallic minerals** | | | | | | | | |
| Gold-quartz | 3,297 | 4 | 1,101 | 38 | 1,334 | 35 | 5,732 | 77 |
| Silver-lead-zinc | 2,173 | 1 | 1,114 | 32 | 1,454 | 38 | 4,741 | 71 |
| Nickel-copper-gold-silver | 10,575 | 17 | 5,588 | 127 | 4,816 | 242 | 20,979 | 386 |
| Iron ore | 192 | 2 | 2,029 | 49 | 4,133 | 173 | 6,354 | 224 |
| Uranium | 2,189 | 5 | 1,356 | 46 | 748 | 57 | 4,293 | 108 |
| Miscellaneous metal mines | 218 | - | 602 | 51 | 391 | 34 | 1,211 | 85 |
| Total | 18,644 | 29 | 11,790 | 343 | 12,876 | 579 | 43,310 | 951 |
| **Industrial minerals** | | | | | | | | |
| Asbestos | 282 | - | 1,184 | 7 | 2,374 | 91 | 3,840 | 98 |
| Gypsum | 81 | - | 368 | 1 | 58 | - | 507 | 1 |
| Peat | - | - | 620 | 15 | 431 | 7 | 1,051 | 22 |
| Potash | 1,313 | 14 | 68 | 1 | 1,495 | 33 | 2,876 | 48 |
| Sand and gravel | - | - | 954 | 6 | 20 | 1 | 974 | 7 |
| Stone | 6 | - | 1,273 | 7 | 253 | 2 | 1,532 | 9 |
| Miscellaneous nonmetals | 359 | - | 326 | 3 | 1,172 | 23 | 1,857 | 26 |
| Total | 2,041 | 14 | 4,793 | 40 | 5,803 | 157 | 12,637 | 211 |
| Mining Total | 20,685 | 43 | 16,583 | 383 | 18,679 | 736 | 55,947 | 1,162 |

- Nil.

TABLE 43. CANADA, LABOUR COSTS IN RELATION TO TONNES MINED, METAL MINES, 1980-82

| Type of Metal Mine | Number of Wage Earners | Total Wages ($000) | Average Annual Wage ($) | Tonnage of Ore Mined (kilotonnes) | Average Annual Tonnes Mined per Wage Earner | Wage Cost per Tonne Mined ($) |
|---|---|---|---|---|---|---|
| **1980** | | | | | | |
| Gold-quartz | 3,946 | 85,102 | 21,567 | 6 346 | 1 608 | 13.41 |
| Nickel-copper-gold-silver | 18,377 | 398,677 | 21,694 | 121 399 | 6 606 | 3.28 |
| Silver-lead-zinc | 3,862 | 91,265 | 23,632 | 16 219 | 4 200 | 5.63 |
| Iron ore | 3,081 | 80,637 | 26,172 | 123 107 | 39 957 | 0.66 |
| Uranium | 3,577 | 87,594 | 24,488 | 7 152 | 2 000 | 12.25 |
| Miscellaneous metals | 812 | 20,604 | 25,374 | 15 871 | 19 546 | 1.30 |
| Total | 33,655 | 763,879 | 22,697 | 290 095 | 8 620 | 2.63 |
| **1981** | | | | | | |
| Gold-quartz | 4,349 | 105,802 | 24,328 | 6 810 | 1 566 | 15.54 |
| Nickel-copper-gold-silver | 18,398 | 433,026 | 23,537 | 137 710 | 7 485 | 3.14 |
| Silver-lead-zinc | 3,832 | 105,381 | 27,500 | 15 964 | 4 166 | 6.60 |
| Iron ore | 2,755 | 86,303 | 31,326 | 118 579 | 43 041 | 0.73 |
| Uranium | 3,796 | 107,707 | 28,374 | 7 454 | 1 964 | 14.45 |
| Miscellaneous metals | 697 | 17,586 | 25,231 | 15 014 | 21 541 | 1.17 |
| Total | 33,827 | 855,805 | 25,299 | 301 530 | 8 914 | 2.84 |
| **1982** | | | | | | |
| Gold-quartz | 4,440 | 125,178 | 28,193 | 8 368 | 1 885 | 14.96 |
| Nickel-copper-gold-silver | 16,307 | 365,743 | 22,429 | 117 833 | 7 226 | 3.10 |
| Silver-lead-zinc | 3,320 | 106,834 | 32,179 | 14 113 | 4 251 | 7.57 |
| Iron ore | 2,272 | 66,205 | 29,139 | 81 963 | 36 075 | 0.81 |
| Uranium | 3,596 | 124,024 | 34,489 | 7 609 | 2 116 | 16.30 |
| Miscellaneous metals | 871 | 25,987 | 29,836 | 8 477 | 9 732 | 3.07 |
| Total | 30,806 | 813,971 | 26,422 | 238 362 | 7 738 | 3.41 |

TABLE 44. CANADA, PERSON-HOURS PAID, PRODUCTION AND RELATED WORKERS, TONNES OF ORE MINED AND ROCK QUARRIED, METAL MINES AND NONMETALLIC MINERAL OPERATIONS, 1976-82

| | Unit | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|---|
| **Metal mines**[1] | | | | | | | | |
| Ore mined | million tonnes | 296.5 | 299.5 | 248.1 | 274.8 | 290.1 | 301.5 | 238.4 |
| Person-hours paid[2] | million | 100.6 | 101.2 | 84.9 | 85.1 | 97.5 | 100.6 | 80.4 |
| Person-hours paid per tonne mine | number | 0.34 | 0.34 | 0.34 | 0.31 | 0.34 | 0.33 | 0.34 |
| Tonnes mined per person-hour paid | tonnes | 2.95 | 2.96 | 2.92 | 3.23 | 2.98 | 3.00 | 2.97 |
| **Nonmetallic mineral operations**[3] | | | | | | | | |
| Ore mined and rock quarried | million tonnes | 162.0 | 200.2 | 200.4 | 192.1 | 185.0 | 164.8 | 113.4 |
| Person-hours paid[2] | million | 26.9 | 27.7 | 26.3 | 27.8 | 26.5 | 23.5 | 18.0 |
| Person-hours paid per tonne mine | number | 0.17 | 0.14 | 0.13 | 0.14 | 0.14 | 0.14 | 0.16 |
| Tonnes mined per person-hour paid | tonnes | 6.02 | 7.23 | 7.62 | 6.91 | 6.98 | 7.01 | 6.30 |

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[1] Excludes placer mining. [2] Man-hours paid for production and related workers only. [3] Includes asbestos, potash, gypsum and stone.

TABLE 45. CANADA, AVERAGE WEEKLY WAGES AND HOURS WORKED, HOURLY-RATED EMPLOYEES IN MINING, MANUFACTURING AND CONSTRUCTION INDUSTRIES, 1977-83

| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983[1] |
|---|---|---|---|---|---|---|---|
| **Mining** | | | | | | | |
| Average hours per week | 40.6 | 40.5 | 41.1 | 40.8 | 40.4 | 39.6 | 38.8 |
| Average weekly wage ($) | 329.45 | 354.51 | 396.58 | 440.61 | 494.62 | 551.68 | 552.79 |
| **Metals** | | | | | | | |
| Average hours per week | 39.8 | 39.4 | 40.4 | 40.1 | 40.2 | 39.0 | 38.3 |
| Average weekly wage ($) | 325.75 | 344.94 | 387.14 | 425.08 | 485.03 | 535.92 | 565.60 |
| **Mineral fuels** | | | | | | | |
| Average hours per week | 41.3 | 41.0 | 40.8 | 41.2 | 41.3 | 42.1 | 39.7 |
| Average weekly wage ($) | 333.51 | 367.34 | 410.38 | 476.30 | 553.71 | 631.91 | 626.12 |
| **Nonmetals** | | | | | | | |
| Average hours per week | 40.3 | 40.5 | 40.3 | 39.5 | 38.7 | 37.2 | 37.5 |
| Average weekly wage ($) | 301.92 | 326.23 | 366.03 | 402.98 | 445.02 | 479.44 | 468.05 |
| **Manufacturing** | | | | | | | |
| Average hours per week | 38.7 | 38.8 | 38.8 | 38.5 | 38.5 | 37.7 | 38.4 |
| Average weekly wage ($) | 246.63 | 265.06 | 287.82 | 314.80 | 352.08 | 384.79 | 406.76 |
| **Construction** | | | | | | | |
| Average hours per week | 38.7 | 39.0 | 39.4 | 39.0 | 38.9 | 38.1 | 36.9 |
| Average weekly wage ($) | 378.50 | 400.58 | 433.51 | 470.45 | 531.54 | 564.33 | 512.26 |

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Note: Wages reflect seasonally adjusted figures.

[1] Ten-month average; new time series.

### TABLE 46. CANADA, AVERAGE WEEKLY WAGES OF HOURLY-RATED EMPLOYEES IN THE MINING INDUSTRY, IN CURRENT AND 1971 DOLLARS, 1977-83

| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983[1] |
|---|---|---|---|---|---|---|---|
| **Current dollars** | | | | | | | |
| All mining | 329.45 | 354.51 | 396.58 | 440.61 | 494.62 | 551.68 | 552.79 |
| Metals | 325.75 | 344.94 | 387.14 | 425.08 | 485.03 | 535.92 | 565.60 |
| Mineral fuels | 333.51 | 367.34 | 414.96 | 476.30 | 553.11 | 631.91 | 626.12 |
| Coal | 303.53 | 323.49 | 362.20 | 430.16 | 485.03 | 562.12 | 564.18 |
| Nonmetals except fuel | 301.92 | 326.23 | 330.47 | 402.98 | 445.02 | 479.44 | 468.05 |
| **1971 dollars** | | | | | | | |
| All mining | 204.88 | 202.35 | 207.42 | 209.22 | 208.79 | 210.16 | 199.04 |
| Metals | 202.58 | 196.88 | 202.48 | 226.16 | 244.74 | 204.16 | 203.65 |
| Mineral fuels | 207.41 | 209.67 | 217.03 | 220.82 | 233.48 | 240.73 | 225.44 |
| Coal | 188.76 | 184.64 | 189.44 | 204.25 | 204.74 | 214.14 | 203.14 |
| Industrial minerals | 187.76 | 186.20 | 172.84 | 191.35 | 187.85 | 182.64 | 168.53 |

Note: Wages reflect seasonally adjusted figures.

[1] Ten month average; new time series.

### TABLE 47. CANADA, INDUSTRIAL FATALITIES PER THOUSAND WORKERS, BY INDUSTRY GROUPS 1981-83[1]

| | Fatalities (number) | | | Number of Workers (000) | | | Rate per 1,000 Workers[2] | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1981 | 1982 | 1983[p] | 1981 | 1982 | 1983[p] | 1981 | 1982 | 1983[p] |
| Agriculture | 17 | 19 | 17 | 151.0 | 149.0 | 156.7 | 0.11 | 0.13 | 0.11 |
| Forestry | 60 | 65 | 59 | 65.6 | 54.3 | 55.3 | 0.91 | 1.20 | 1.07 |
| Fishing | 20 | 18 | 15 | 13.8 | 11.4 | 14.7 | 1.45 | 1.58 | 1.02 |
| Mining | 126 | 146 | 90 | 178.0 | 155.5 | 146.7 | 0.71 | 0.94 | 0.61 |
| Manufacturing | 146 | 170 | 128 | 1,883.9 | 1,709.2 | 1,712.6 | 0.08 | 0.10 | 0.07 |
| Construction | 174 | 140 | 100 | 475.1 | 409.7 | 351.4 | 0.37 | 0.34 | 0.28 |
| Transportation | 198 | 172 | 121 | 849.6 | 826.4 | 79.0 | 0.23 | 0.21 | 0.15 |
| Trade | 60 | 66 | 54 | 1,629.0 | 1,575.9 | 1,491.2 | 0.04 | 0.04 | 0.04 |
| Finance | 9 | 5 | 2 | 533.1 | 534.7 | 520.0 | 0.02 | 0.01 | 0.04 |
| Service | 83 | 79 | 56 | 2,932.4 | 2,965.9 | 2,844.0 | 0.03 | 0.03 | 0.02 |
| Public administration | 62 | 53 | 48 | 628.3 | 646.6 | 655.8 | 0.10 | 0.08 | 0.07 |
| Unknown | 5 | 7 | 2 | .. | .. | .. | .. | .. | .. |
| Total | 960 | 940 | 694 | 9,339.8 | 9,038.6 | 8,738.4 | 0.10 | 0.10 | 0.08 |

Note: See footnotes on next table.

[1] Includes fatalities resulting from occupational chest diseases such as silicosis, lung cancer, etc. [2] The rates may be understated because only 80 per cent of workers in the Statistics Canada employment estimates are covered by workers' compensation.

[p] Preliminary; .. Not available.

## TABLE 48. CANADA, INDUSTRIAL FATALITIES PER THOUSAND WORKERS, BY INDUSTRY GROUPS, 1977-83

| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983P |
|---|---|---|---|---|---|---|---|
| Agriculture | 0.11 | 0.05 | 0.10 | 0.05 | 0.11 | 0.13 | 0.11 |
| Forestry | 0.92 | 1.28 | 1.51 | 1.11 | 0.91 | 1.20 | 1.07 |
| Fishing[1] | 2.37 | 1.44 | 1.25 | 1.47 | 1.45 | 1.58 | 1.02 |
| Mining[2] | 0.92 | 0.82 | 0.93 | 0.99 | 0.71 | 0.94 | 0.61 |
| Manufacturing | 0.10 | 0.10 | 0.09 | 0.08 | 0.08 | 0.10 | 0.07 |
| Construction | 0.37 | 0.38 | 0.38 | 0.40 | 0.37 | 0.34 | 0.28 |
| Transportation[3] | 0.22 | 0.25 | 0.26 | 0.26 | 0.23 | 0.21 | 0.15 |
| Trade | 0.05 | 0.04 | 0.04 | 0.05 | 0.04 | 0.04 | 0.04 |
| Finance[4] | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | -- |
| Service[5] | 0.03 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 |
| Public administration | 0.08 | 0.12 | 0.10 | 0.07 | 0.10 | 0.08 | 0.07 |
| Total | 0.11 | 0.12 | 0.12 | 0.12 | 0.10 | 0.10 | 0.08 |

[1] Includes trapping and hunting. [2] Includes quarrying and oil wells. [3] Includes storage, communication, electric power and water utilities and highway maintenance. [4] Includes insurance and real estate. [5] Includes community, business and personal service.

P Preliminary; -- Too small to be expressed.

## TABLE 49. CANADA, INDUSTRIAL FATALITIES BY OCCUPATIONAL INJURIES AND ILLNESSES[1], 1981-83

| | Occupational Injuries | | | Occupational Illnesses | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1981 | 1982 | 1983P | 1981 | 1982 | 1983P | 1981 | 1982 | 1983P |
| Agriculture | 12 | 13 | 12 | 0 | 0 | 0 | 12 | 13 | 12 |
| Forestry | 49 | 54 | 54 | 0 | 0 | 0 | 49 | 54 | 54 |
| Fishing | 20 | 17 | 15 | 0 | 0 | 0 | 20 | 17 | 15 |
| Mining | 70 | 96 | 39 | 52 | 48 | 48 | 122 | 144 | 87 |
| Manufacturing | 83 | 99 | 82 | 40 | 49 | 32 | 123 | 148 | 114 |
| Construction | 149 | 107 | 79 | 6 | 13 | 14 | 155 | 120 | 93 |
| Transportation | 176 | 155 | 107 | 1 | 6 | 3 | 177 | 161 | 110 |
| Trade | 47 | 57 | 42 | 1 | 0 | 1 | 48 | 57 | 43 |
| Finance | 6 | 4 | 2 | 0 | 0 | 0 | 6 | 4 | 2 |
| Service | 64 | 57 | 49 | 3 | 3 | 2 | 67 | 60 | 51 |
| Public administration | 48 | 42 | 39 | 2 | 1 | 1 | 50 | 43 | 40 |
| Unknown | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Total | 725 | 701 | 520 | 105 | 120 | 101 | 830 | 821 | 621 |

[1] Excludes the Province of Quebec for which data is unavailable.

P Preliminary.

## TABLE 50. CANADA, NUMBER OF STRIKES AND LOCKOUTS BY INDUSTRIES, 1981-83

| | 1981 | | | 1982 | | | 1983 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Strikes and Lockouts | Workers Involved | Duration in Person-days | Strikes and Lockouts | Workers Involved | Duration in Person-days | Strikes and Lockouts | Workers Involved | Duration in Person-days |
| Agriculture | 3 | 65 | 7,750 | 3 | 64 | 7,320 | 2 | 26 | 770 |
| Forestry | 14 | 3,292 | 349,400 | 3 | 215 | 7,840 | 5 | 1,326 | 13,890 |
| Fishing and trapping | 1 | 400 | 330 | 0 | 0 | 0 | 1 | 3,000 | 3,000 |
| Mines | 42 | 24,359 | 580,720 | 8 | 12,686 | 257,140 | 12 | 11,889 | 178,390 |
| Manufacturing | 423 | 152,207 | 4,638,290 | 292 | 63,959 | 1,690,560 | 311 | 64,206 | 1,385,290 |
| Construction | 44 | 5,780 | 43,280 | 63 | 94,228 | 2,199,610 | 24 | 9,394 | 243,680 |
| Transportation and utilities | 101 | 58,135 | 1,513,970 | 67 | 24,005 | 565,740 | 63 | 15,257 | 275,000 |
| Trade | 90 | 4,886 | 149,170 | 72 | 4,465 | 171,180 | 74 | 14,831 | 251,690 |
| Finance, insurance and real estate | 18 | 3,480 | 294,760 | 15 | 746 | 49,620 | 17 | 606 | 9,600 |
| Service | 221 | 57,248 | 577,400 | 110 | 27,846 | 415,380 | 104 | 168,376 | 1,770,710 |
| Public administration | 90 | 17,696 | 717,420 | 43 | 36,088 | 251,030 | 32 | 40,398 | 311,940 |
| Various industries | 1 | 6,000 | 6,000 | 1 | 180,000 | 180,000 | 0 | 0 | 0 |
| All industries | 1,048 | 338,548 | 8,878,490 | 677 | 444,302 | 5,795,420 | 645 | 329,309 | 4,443,960 |

## TABLE 51. CANADA, NUMBER OF STRIKES AND LOCKOUTS BY MINING AND MINERAL MANUFACTURING INDUSTRIES, 1981-83

| | 1981 | | | 1982 | | | 1983 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Strikes and Lockouts | Workers Involved | Duration in Person-days | Strikes and Lockouts | Workers Involved | Duration in Person-days | Strikes and Lock-outs | Workers Involved | Duration in Person-days |
| **Mines** | 42 | 24,359 | 580,720 | 8 | 12,686 | 257,140 | 12 | 11,889 | 178,390 |
| Metal | 25 | 11,457 | 248,930 | 2 | 10,211 | 248,300 | 6 | 6,046 | 91,500 |
| Mineral fuels | 9 | 11,159 | 306,690 | 2 | 2,400 | 4,670 | 3 | 4,991 | 80,950 |
| Nonmetals | 5 | 1,674 | 16,130 | 0 | 0 | 0 | 2 | 847 | 5,540 |
| Quarries | 3 | 69 | 8,970 | 4 | 75 | 4,170 | 1 | 5 | 400 |
| **Mineral manufacturing** | 62 | 30,770 | 1,553,000 | 29 | 6,839 | 291,600 | 32 | 4,334 | 118,540 |
| Primary metals | 29 | 27,169 | 1,429,150 | 11 | 4,259 | 199,900 | 15 | 2,609 | 88,070 |
| Nonmetallic mineral products | 33 | 3,601 | 123,850 | 17 | 2,576 | 91,600 | 17 | 1,725 | 30,470 |
| Petroleum and coal products | 0 | 0 | 0 | 1 | 4 | 100 | 0 | 0 | 0 |

TABLE 52. CANADA, SOURCE OF ORES HOISTED OR REMOVED FROM SELECTED TYPES OF MINES, 1980-82

| Mines | 1980 Under-ground | 1980 Open-pit | 1980 Total | 1981 Under-ground | 1981 Open-pit | 1981 Total | 1982 Under-ground | 1982 Open-pit | 1982 Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | (kilotonnes) | | | | |
| Asbestos | 1 997 | 26 106 | 28 103 | 1 789 | 23 874 | 25 664 | 1 308 | 16 184 | 17 492 |
| Gold-quartz | 5 193 | 1 153 | 6 346 | 5 835 | 975 | 6 810 | 6 710 | 1 657 | 8 367 |
| Gypsum | 1 062 | 6 549 | 7 611 | 685 | 5 535 | 6 220 | 475 | 5 355 | 5 830 |
| Iron ore | 3 222 | 119 886 | 123 107 | 3 269 | 115 309 | 118 579 | 2 448 | 79 515 | 81 963 |
| Nickel-copper-gold-silver | 30 840 | 90 559 | 121 399 | 31 193 | 106 516 | 137 710 | 21 431 | 96 402 | 117 833 |
| Silver-lead-zinc | 9 822 | 6 397 | 16 219 | 9 943 | 6 021 | 15 964 | 9 950 | 4 163 | 14 113 |
| Uranium | 5 981 | 1 171 | 7 152 | 6 664 | 790 | 7 454 | 6 900 | 709 | 7 609 |
| Miscellaneous metals | 1 491 | 14 381 | 15 871 | 1 518 | 13 496 | 15 014 | 1 517 | 6 959 | 8 476 |
| Total | 59 608 | 266 201 | 325 809 | 60 896 | 272 516 | 333 415 | 50 739 | 210 944 | 261 683 |
| Percentage | 18.3 | 81.7 | 100.0 | 18.3 | 81.7 | 100.0 | 19.4 | 80.6 | 100.0 |

TABLE 53. CANADA, SOURCE OF MATERIAL HOISTED OR REMOVED FROM METAL MINES, 1982

| | Underground Ore | Underground Waste | Open-pit Ore | Open-pit Waste | Open-pit Overburden |
|---|---|---|---|---|---|
| | | | (kilotonnes) | | |
| Gold-quartz | 6 710 | 767 | 1 657 | 1 228 | 10 558 |
| Nickel-copper-gold-silver | 21 431 | 2 152 | 96 402 | 98 990 | 52 046 |
| Silver-lead-zinc | 9 950 | 1 089 | 4 163 | 22 152 | 16 537 |
| Iron | 2 448 | 71 | 79 515 | 30 223 | 12 568 |
| Uranium | 6 900 | 300 | 709 | 1 181 | - |
| Miscellaneous metals | 1 517 | 101 | 6 959 | 13 645 | 10 |
| Total | 48 956 | 4 480 | 189 405 | 167 419 | 91 719 |

- Nil.

TABLE 54. CANADA, ORE MINED AND ROCK QUARRIED IN THE MINING INDUSTRY, 1976-82

| | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|
| | | | | (kilotonnes) | | | |
| **Metals** | | | | | | | |
| Gold-quartz | 5 921 | 5 768 | 5 914 | 5 478 | 6 346 | 6 810 | 8 368 |
| Silver-lead-zinc | 14 309 | 16 730 | 15 859 | 15 078 | 16 219 | 15 964 | 14 113 |
| Nickel-copper-gold-silver | 125 062 | 129 361 | 109 613 | 109 437 | 121 399 | 137 709 | 117 833 |
| Iron | 133 073 | 127 057 | 96 323 | 130 799 | 123 107 | 118 579 | 81 963 |
| Uranium | 3 663 | 5 014 | 6 126 | 6 141 | 7 152 | 7 454 | 7 608 |
| Miscellaneous metals | 14 499 | 15 599 | 14 221 | 7 822 | 15 871 | 15 014 | 8 477 |
| Total | 296 527 | 299 528 | 248 056 | 274 755 | 290 095 | 301 530 | 238 362 |
| **Nonmetals** | | | | | | | |
| Asbestos | 31 055 | 31 912 | 28 788 | 31 522 | 28 103 | 25 664 | 17 493 |
| Potash | 20 277 | 24 813 | 24 856 | 25 511 | 26 988 | 30 344 | 16 946 |
| Gypsum | 5 978 | 7 216 | 8 393 | 8 310 | 7 611 | 6 220 | 5 830 |
| Rock salt | 5 080 | 4 974 | 5 050 | 5 639 | 5 321 | 4 927 | 5 723 |
| Total | 62 390 | 68 915 | 67 087 | 70 982 | 68 023 | 67 155 | 45 992 |
| **Structural materials** | | | | | | | |
| Stone, all kinds quarried[1] | 87 876 | 120 163 | 122 144 | 109 719 | 103 366 | 86 860 | 59 181 |
| Stone used to make cement | 13 350 | 12 614 | 13 051 | 13 982 | 14 138 | 14 047 | 10 593 |
| Stone used to make lime | 3 442 | 3 534 | 3 178 | 3 028 | 4 751 | 1 626 | 3 411 |
| Total | 104 668 | 136 310 | 138 373 | 126 729 | 122 255 | 102 533 | 73 085 |
| Total ore mined and rock quarried | 463 585 | 504 753 | 453 516 | 472 466 | 480 373 | 471 218 | 357 439 |

[1] Excludes stone used to manufacture cement and lime.

TABLE 55. CANADA, EXPLORATION AND CAPITAL EXPENDITURES IN THE MINING INDUSTRY[1], BY PROVINCES AND TERRITORIES, 1980-82

| | | Capital | | | | | | Repair | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Construction | | | | | | | | | | | | |
| | | On-Property Exploration | On-Property Development | Structures | Total | Machinery and Equipment | Total Capital | Construction | Machinery and Equipment | Total Repair | Total Capital and Repair | Outside or General Exploration | Land and Mining Rights | Total, all Expenditures |
| | | | | | | | ($ million) | | | | | | | |
| Atlantic Provinces | 1980 | 2.7 | 60.3 | 22.4 | 85.4 | 60.0 | 145.4 | 14.8 | 168.2 | 183.0 | 328.4 | 35.5 | 0.2 | 364.1 |
| | 1981 | 6.3 | 63.5 | 80.7 | 150.5 | 115.4 | 265.9 | 11.0 | 185.2 | 196.2 | 462.1 | 43.7 | 1.5 | 507.3 |
| | 1982P | 9.4 | 78.5 | 103.7 | 191.6 | 105.1 | 296.7 | 16.3 | 174.1 | 190.4 | 487.1 | 20.0 | 0.7 | 507.8 |
| Quebec | 1980 | 15.6 | 151.6 | 81.3 | 248.5 | 98.8 | 347.3 | 45.4 | 281.8 | 327.2 | 674.5 | 58.5 | 9.2 | 742.2 |
| | 1981 | 28.0 | 156.1 | 106.5 | 290.6 | 135.9 | 426.5 | 49.3 | 261.7 | 311.0 | 737.5 | 81.7 | 2.1 | 821.3 |
| | 1982P | 32.5 | 135.5 | 54.6 | 222.6 | 81.7 | 304.3 | 43.5 | 197.0 | 240.5 | 544.8 | 61.5 | 0.4 | 606.7 |
| Ontario | 1980 | 12.1 | 179.3 | 124.5 | 315.9 | 120.2 | 436.1 | 66.2 | 235.9 | 302.1 | 738.2 | 58.5 | 3.4 | 800.1 |
| | 1981 | 17.9 | 206.2 | 148.8 | 372.9 | 177.2 | 550.1 | 70.6 | 281.7 | 352.3 | 902.4 | 79.5 | 6.4 | 988.3 |
| | 1982P | 21.6 | 206.0 | 153.8 | 381.4 | 115.3 | 496.7 | 30.9 | 268.4 | 299.3 | 796.0 | 66.4 | 1.7 | 864.1 |
| Manitoba | 1980 | (2) | (2) | (2) | 39.2 | 11.3 | 50.5 | 6.6 | 44.2 | 50.8 | 101.3 | 21.2 | 0.3 | 122.8 |
| | 1981 | 8.3 | 27.3 | 13.5 | 49.1 | 34.0 | 83.1 | 5.1 | 44.2 | 49.3 | 132.4 | 20.6 | 0.3 | 153.3 |
| | 1982P | (2) | (2) | (2) | 47.3 | 17.0 | 64.3 | 4.1 | 29.6 | 33.7 | 98.0 | 13.9 | (2) | (2) |
| Saskatchewan | 1980 | 7.0 | 40.4 | 62.1 | 109.5 | 87.1 | 196.6 | 9.1 | 90.3 | 99.4 | 296.0 | 56.4 | 4.7 | 357.1 |
| | 1981 | 20.2 | 39.0 | 101.6 | 160.8 | 175.7 | 336.5 | 11.5 | 120.5 | 132.0 | 468.5 | 45.4 | 8.1 | 522.0 |
| | 1982P | 16.2 | 42.2 | 163.0 | 221.4 | 189.6 | 411.0 | 9.6 | 117.4 | 127.0 | 538.0 | 44.4 | 1.4 | 583.8 |
| Alberta | 1980 | (2) | (2) | (2) | 34.5 | 41.8 | 76.3 | 1.2 | 57.5 | 58.7 | 135.0 | 14.2 | (2) | (2) |
| | 1981 | 2.6 | 20.1 | 52.6 | 75.3 | 52.2 | 127.5 | 0.9 | 59.0 | 59.9 | 187.4 | 23.9 | (2) | (2) |
| | 1982P | (2) | (2) | (2) | 65.5 | 141.5 | 207.0 | 3.6 | 76.3 | 79.9 | 286.3 | 21.9 | (2) | (2) |
| British Columbia | 1980 | 31.1 | 154.1 | 302.6 | 487.8 | 233.3 | 721.1 | 21.8 | 232.5 | 254.3 | 975.4 | 91.0 | 3.7 | 1,070.1 |
| | 1981 | 34.9 | 139.7 | 490.3 | 664.9 | 197.2 | 862.1 | 24.1 | 338.9 | 363.0 | 1,225.1 | 111.7 | 1.5 | 1,338.3 |
| | 1982P | 19.5 | 186.1 | 474.8 | 680.4 | 203.3 | 883.7 | 25.4 | 317.9 | 343.3 | 1,227.0 | 61.0 | 1.8 | 1,289.8 |
| Yukon and Northwest Territories | 1980 | 8.6 | 26.9 | 99.2 | 134.7 | 82.3 | 217.0 | 4.7 | 50.4 | 55.1 | 272.1 | 68.3 | (2) | (2) |
| | 1981 | 16.3 | 43.4 | 155.3 | 215.0 | 106.5 | 321.5 | 5.4 | 57.4 | 63.8 | 384.3 | 78.2 | (2) | (2) |
| | 1982P | 7.7 | 35.0 | 36.7 | 79.4 | 80.4 | 159.8 | 7.6 | 56.2 | 63.8 | 223.6 | 73.3 | (2) | (2) |
| Canada | 1980 | 85.4 | 646.8 | 723.3 | 1,455.5 | 734.8 | 2,190.3 | 169.8 | 1,160.8 | 1,330.6 | 3,520.9 | 403.6 | 43.6 | 3,968.1 |
| | 1981 | 134.5 | 695.3 | 1,149.3 | 1,979.1 | 994.1 | 2,973.2 | 177.9 | 1,348.6 | 1,526.5 | 4,499.7 | 484.7 | 29.8 | 5,014.2 |
| | 1982P | 115.6 | 724.5 | 1,048.9 | 1,889.0 | 933.9 | 2,822.9 | 141.0 | 1,236.9 | 1,377.9 | 4,200.8 | 362.4 | 32.5 | 4,595.7 |

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[1] Excludes the crude oil and natural gas industries as well as overhead expenditures; (2) Confidential, included in total.
P Preliminary.

TABLE 56. CANADA, EXPLORATION AND CAPITAL EXPENDITURES[1] IN THE MINING INDUSTRY, BY TYPE OF MINING, 1980-82

|  |  | Capital |  |  |  |  |  | Repair |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  | Construction |  |  |  |  |  |  |  |  |  |  |
|  |  | On-Property Exploration | On-Property Development | Structures | Total | Machinery and Equipment | Total Capital | Construction | Machinery and Equipment | Total Repair | Total Capital and Repair | Outside or General Exploration | Land and Mining Rights | Total, all Expenditures |
|  |  |  |  |  |  |  | ($ million) |  |  |  |  |  |  |  |
| **Metal Mining** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Gold | 1980 | 22.6 | 63.4 | 36.7 | 122.7 | 38.2 | 160.9 | 6.8 | 27.9 | 34.7 | 195.6 | 20.0 | (2) | 215.6 |
|  | 1981 | 21.7 | 111.8 | 179.7 | 313.2 | 96.3 | 409.5 | 13.9 | 44.7 | 58.6 | 468.1 | 40.1 | 2.7 | 510.9 |
|  | 1982P | 27.8 | 118.0 | 135.4 | 281.2 | 98.2 | 379.4 | 11.5 | 47.2 | 58.7 | 438.1 | 10.8 | (2) | 448.9 |
| Copper-gold-silver | 1980 | 24.1 | 93.3 | 187.6 | 305.0 | 185.9 | 490.9 | 24.2 | 211.0 | 235.2 | 726.1 | 8.4 | (2) | 734.5 |
|  | 1981 | 28.2 | 91.2 | 157.1 | 276.5 | 161.6 | 438.1 | 29.7 | 292.2 | 321.9 | 760.0 | 13.5 | 0.6 | 774.1 |
|  | 1982P | 28.9 | 82.0 | 42.9 | 153.8 | 52.2 | 206.0 | 22.3 | 241.9 | 264.2 | 470.2 | 12.3 | (2) | 482.5 |
| Silver-lead-zinc | 1980 | 9.4 | 35.4 | 97.1 | 141.9 | 86.1 | 228.0 | 7.0 | 61.4 | 68.4 | 296.4 | 10.7 | (2) | 307.1 |
|  | 1981 | 21.5 | 55.2 | 95.4 | 172.1 | 104.7 | 276.8 | 6.8 | 75.4 | 82.2 | 359.0 | 15.4 | 0.6 | 375.0 |
|  | 1982P | 11.3 | 48.8 | 27.0 | 87.1 | 57.2 | 144.3 | 13.6 | 106.0 | 119.6 | 263.9 | 6.2 | (2) | 270.1 |
| Iron | 1980 | (2) | (2) | 26.3 | 123.9 | 44.1 | 168.0 | 39.2 | 298.0 | 337.2 | 505.2 | (2) | (2) | 505.2 |
|  | 1981 | (2) | (2) | 19.9 | 127.9 | 60.4 | 188.3 | 35.6 | 302.8 | 338.4 | 526.7 | (2) | (2) | 526.7 |
|  | 1982P | (2) | (2) | 23.3 | 98.1 | 40.0 | 138.1 | 37.7 | 232.7 | 270.4 | 408.5 | (2) | (2) | 408.5 |
| Other metal mining | 1980 | 14.7 | 178.8 | 214.3 | 407.8 | 109.3 | 517.1 | 60.1 | 169.1 | 229.2 | 746.3 | (2) | (2) | 746.3 |
|  | 1981 | 37.3 | 198.6 | 204.0 | 439.9 | 149.1 | 589.0 | 65.8 | 184.8 | 250.6 | 839.6 | (2) | (2) | 839.6 |
|  | 1982P | 21.8 | 194.3 | 172.3 | 388.4 | 118.7 | 507.1 | 27.3 | 176.9 | 204.2 | 711.3 | (2) | (2) | 711.3 |
| Total metal mining | 1980 | (2) | (2) | 562.0 | 1,101.3 | 463.6 | 1,564.9 | 137.3 | 767.4 | 904.7 | 2,469.6 | 54.4 | 24.9 | 2,548.9 |
|  | 1981 | (2) | (2) | 656.1 | 1,329.6 | 572.1 | 1,901.7 | 151.8 | 899.9 | 1,051.7 | 2,953.4 | 97.0 | 4.4 | 3,054.8 |
|  | 1982P | (2) | (2) | 400.9 | 1,008.6 | 366.3 | 1,374.9 | 112.4 | 804.7 | 917.1 | 2,292.0 | 35.2 | 1.2 | 2,328.4 |
| **Nonmetal mining** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Asbestos | 1980 | 0.7 | 56.4 | 8.0 | 65.1 | 23.1 | 88.2 | 7.4 | 106.0 | 113.4 | 201.6 | (2) | (2) | 201.6 |
|  | 1981 | (2) | (2) | 5.5 | 53.7 | 15.3 | 69.0 | 4.0 | 79.5 | 83.5 | 152.5 | (2) | (2) | 152.5 |
|  | 1982P | (2) | (2) | 3.2 | 36.6 | 8.9 | 45.5 | 3.7 | 55.7 | 59.4 | 104.9 | (2) | (2) | 104.9 |
| Other non-metal mining | 1980 | 9.6 | 120.8 | 150.9 | 281.3 | 244.5 | 525.8 | 25.1 | 287.1 | 312.2 | 838.0 | (2) | (2) | 838.0 |
|  | 1981 | 21.3 | 85.4 | 487.4 | 594.1 | 402.4 | 996.5 | 22.0 | 368.3 | 390.3 | 1,386.8 | (2) | 12.6 | 1,399.4 |
|  | 1982P | 19.6 | 174.4 | 644.2 | 838.2 | 554.4 | 1,392.6 | 24.9 | 376.1 | 401.0 | 1,793.6 | (2) | 28.6 | 1,822.2 |
| Total non-metal mining | 1980 | 10.3 | 177.2 | 158.9 | 346.4 | 267.6 | 614.0 | 32.5 | 393.1 | 425.6 | 1,039.6 | 18.4 | 9.4 | 1,067.4 |
|  | 1981 | (2) | (2) | 492.9 | 647.8 | 417.7 | 1,065.5 | 26.0 | 447.8 | 473.8 | 1,539.3 | 38.5 | 12.6 | 1,590.4 |
|  | 1982P | (2) | (2) | 647.4 | 874.8 | 563.3 | 1,438.1 | 28.6 | 431.8 | 460.4 | 1,898.5 | 31.3 | 28.6 | 1,958.4 |
| **Metal and nonmetal exploration** | 1980 | (2) | (2) | 2.4 | 7.8 | 3.6 | 11.4 | - | 0.3 | 0.3 | 11.7 | 330.8 | 9.3 | 351.8 |
|  | 1981 | (2) | (2) | 0.3 | 1.7 | 4.3 | 6.0 | 0.1 | 0.9 | 1.0 | 7.0 | 349.2 | 12.8 | 369.0 |
|  | 1982P | (2) | (2) | 0.6 | 5.6 | 4.3 | 9.9 | - | 0.4 | 0.4 | 10.3 | 295.9 | 2.7 | 308.9 |
| Total mining | 1980 | 85.4 | 646.8 | 723.3 | 1,455.5 | 734.8 | 2,190.3 | 169.8 | 1,160.8 | 1,330.6 | 3,520.9 | 403.6 | 43.6 | 3,968.1 |
|  | 1981 | 134.5 | 695.3 | 1,149.3 | 1,979.1 | 994.1 | 2,773.2 | 177.9 | 1,348.6 | 1,526.5 | 4,499.7 | 404.7 | 29.8 | 5,014.2 |
|  | 1982P | 115.6 | 724.5 | 1,048.9 | 1,889.0 | 933.9 | 2,822.9 | 141.0 | 1,236.9 | 1,377.9 | 4,200.8 | 362.4 | 32.5 | 4,595.7 |

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[1] Excludes expenditures in the petroleum and natural gas industries as well as overhead expenditures. (2) Confidential, included in total.
P Preliminary; - Nil.

TABLE 57. CANADA, DIAMOND DRILLING IN THE MINING INDUSTRY, BY MINING COMPANIES WITH OWN EQUIPMENT AND BY DRILLING CONTRACTORS, 1980-82

| | | 1980 | | | 1981 | | | 1982 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Exploration | Other | Total | Exploration | Other | Total | Exploration | Other | Total |
| | | | | | | (metres) | | | | |
| **Metal mining** | | | | | | | | | | |
| Gold-quartz | Own equipment | 27 775 | 1 000 | 28 775 | 45 162 | 1 524 | 46 686 | 57 957 | 3 262 | 61 219 |
| | Contractors | 154 812 | 4 048 | 158 860 | 234 432 | 25 079 | 259 511 | 227 202 | - | 227 202 |
| | Total | 182 587 | 5 048 | 187 635 | 279 594 | 26 603 | 306 197 | 285 159 | 3 262 | 288 421 |
| Nickel-copper-gold-silver | Own equipment | 239 469 | - | 239 469 | 318 530 | 223 | 318 753 | 111 189 | 13 423 | 124 612 |
| | Contractors | 286 536 | 40 605 | 327 141 | 355 586 | 1 373 | 356 959 | 203 357 | 58 971 | 262 328 |
| | Total | 526 005 | 40 605 | 566 610 | 674 116 | 1 596 | 674 712 | 314 546 | 72 394 | 386 940 |
| Silver-lead-zinc and silver-cobalt | Own equipment | 42 161 | 19 545 | 61 706 | 68 716 | 199 151 | 267 867 | 79 110 | 171 989 | 251 099 |
| | Contractors | 198 171 | - | 198 171 | 207 126 | 3 761 | 210 887 | 173 119 | - | 173 119 |
| | Total | 240 332 | 19 545 | 259 877 | 275 842 | 202 912 | 478 754 | 252 229 | 171 989 | 424 218 |
| Iron mines | Own equipment | 38 424 | - | 38 424 | - | - | - | - | - | - |
| | Contractors | 30 007 | 27 474 | 57 481 | 15 817 | - | 15 817 | 22 067 | - | 22 067 |
| | Total | 68 431 | 27 474 | 95 905 | 15 817 | - | 15 817 | 22 067 | - | 22 067 |
| Uranium | Own equipment | - | - | - | 28 279 | - | 28 279 | 41 645 | - | 41 645 |
| | Contractors | 10 884 | - | 10 884 | 59 232 | 21 668 | 80 900 | 45 714 | 13 362 | 59 076 |
| | Total | 10 884 | - | 10 884 | 87 511 | 21 668 | 109 179 | 87 359 | 13 362 | 100 721 |
| Miscellaneous metal mining | Own equipment | - | - | - | - | - | - | - | - | - |
| | Contractors | 67 156 | - | 67 156 | 45 373 | - | 45 373 | 41 954 | - | 41 954 |
| | Total | 67 156 | - | 67 156 | 45 373 | - | 45 373 | 41 954 | - | 41 954 |
| Total metal mining | Own equipment | 347 829 | 20 545 | 368 374 | 460 687 | 200 898 | 661 585 | 289 901 | 188 674 | 478 575 |
| | Contractors | 747 566 | 72 127 | 819 093 | 917 566 | 51 881 | 969 447 | 713 413 | 72 333 | 785 746 |
| | Total | 1 095 395 | 92 672 | 1 188 067 | 1 378 253 | 252 779 | 1 631 032 | 1 003 314 | 261 007 | 1 264 321 |
| **Nonmetal mining** | | | | | | | | | | |
| Asbestos | Own equipment | - | - | - | - | - | - | - | - | - |
| | Contractors | 28 790 | - | 28 790 | 10 814 | - | 10 814 | 8 400 | - | 8 400 |
| | Total | 28 790 | - | 28 790 | 10 814 | - | 10 814 | 8 400 | - | 8 400 |
| Gypsum | Own equipment | 1 314 | - | 1 314 | - | - | - | - | - | - |
| | Contractors | 4 463 | - | 4 463 | 1 841 | - | 1 841 | - | - | - |
| | Total | 5 777 | - | 5 777 | 1 841 | - | 1 841 | - | - | - |
| Salt | Own equipment | - | - | - | 1 552 | - | 1 552 | - | - | - |
| | Contractors | - | - | - | - | - | - | - | - | - |
| | Total | - | - | - | 1 552 | - | 1 552 | - | - | - |
| Miscellaneous nonmetal mining | Own equipment | 2 844 | - | 2 844 | 404 | - | 404 | 1 073 | - | 1 073 |
| | Contractors | 798 | - | 798 | 1 128 | - | 1 128 | 3 596 | - | 3 596 |
| | Total | 3 642 | - | 3 642 | 1 532 | - | 1 532 | 4 669 | - | 4 669 |
| Total nonmetal mining | Own equipment | 4 158 | - | 4 158 | 1 956 | - | 1 956 | 1 073 | - | 1 073 |
| | Contractors | 34 051 | - | 34 051 | 13 783 | - | 13 783 | 11 996 | - | 11 996 |
| | Total | 38 209 | - | 38 209 | 15 739 | - | 15 739 | 13 069 | - | 13 069 |
| Total mining industry | Own equipment | 351 987 | 20 545 | 372 532 | 462 648 | 200 898 | 663 541 | 290 974 | 188 674 | 479 648 |
| | Contractors | 781 617 | 72 127 | 853 744 | 931 349 | 51 881 | 983 230 | 725 409 | 72 333 | 797 742 |
| | Total | 1 133 604 | 92 672 | 1 226 276 | 1 393 992 | 252 779 | 1 641 771 | 1 016 383 | 261 007 | 1 277 390 |

- Nil.

## TABLE 58. CANADA, ORE MINED AND ROCK QUARRIED IN THE MINING INDUSTRY, 1953-82

| | Metals | Nonmetal[1] | Total |
|---|---|---|---|
| | | (million tonnes) | |
| 1953 | 49.3 | 42.8 | 92.1 |
| 1954 | 53.5 | 55.7 | 109.2 |
| 1955 | 62.7 | 57.6 | 120.3 |
| 1956 | 70.2 | 66.2 | 136.4 |
| 1957 | 76.4 | 74.5 | 150.9 |
| 1958 | 71.4 | 71.2 | 142.6 |
| 1959 | 89.9 | 82.2 | 172.1 |
| 1960 | 92.1 | 88.7 | 180.8 |
| 1961 | 90.1 | 96.7 | 186.8 |
| 1962 | 103.6 | 103.8 | 207.4 |
| 1963 | 112.7 | 120.4 | 233.1 |
| 1964 | 128.0 | 134.1 | 262.1 |
| 1965 | 151.0 | 146.5 | 297.5 |
| 1966 | 147.6 | 171.8 | 319.4 |
| 1967 | 169.1 | 177.5 | 346.6 |
| 1968 | 186.9 | 172.7 | 359.6 |
| 1969 | 172.0 | 178.8 | 350.8 |
| 1970 | 213.0 | 179.1 | 392.1 |
| 1971 | 211.5 | 185.8 | 397.3 |
| 1972 | 206.0 | 189.7 | 395.7 |
| 1973 | 274.8 | 162.6 | 437.3 |
| 1974 | 278.7 | 178.8 | 457.6 |
| 1975 | 264.2 | 158.7 | 422.9 |
| 1976 | 296.5 | 167.1 | 463.6 |
| 1977 | 299.5 | 205.2 | 504.8 |
| 1978 | 248.1 | 205.5 | 453.5 |
| 1979 | 274.8 | 197.7 | 472.5 |
| 1980 | 290.1 | 190.3 | 480.4 |
| 1981 | 301.5 | 169.7 | 471.2 |
| 1982 | 238.4 | 119.1 | 357.4 |

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[1] Includes nonmetallic mineral mining and all stone quarried, including stone used to make cement and lime. From 1973 onwards, coverage is the same as in Table 54.

## TABLE 59. CANADA, TOTAL DIAMOND DRILLING, METAL DEPOSITS, 1953-82

| | Gold-quartz Deposits | Copper-gold-silver and nickel-copper Deposits | Silver-lead-zinc and silver-cobalt Deposits | Other Metal Bearing Deposits[1] | Total Metal Deposits |
|---|---|---|---|---|---|
| | | | (metres) | | |
| 1953 | 675 598 | 976 514 | 367 864 | 65 279 | 2 085 255 |
| 1954 | 737 266 | 826 288 | 271 873 | 199 097 | 2 034 524 |
| 1955 | 71 674 | 875 942 | 341 857 | 537 612 | 2 473 085 |
| 1956 | 682 600 | 1 490 298 | 399 679 | 383 431 | 2 956 008 |
| 1957 | 706 273 | 1 098 490 | 323 704 | 287 364 | 2 415 831 |
| 1958 | 546 361 | 923 026 | 297 792 | 286 970 | 2 054 649 |
| 1959 | 558 160 | 1 110 664 | 282 088 | 383 471 | 2 334 383 |
| 1960 | 628 016 | 1 267 792 | 226 027 | 315 067 | 2 436 902 |
| 1961 | 503 741 | 1 128 091 | 255 101 | 221 079 | 2 199 452 |
| 1962 | 902 288 | 1 025 048 | 350 180 | 358 679 | 2 636 195 |
| 1963 | 529 958 | 977 257 | 288 204 | 148 703 | 1 944 122 |
| 1964 | 458 933 | 709 588 | 401 099 | 104 738 | 1 674 358 |
| 1965 | 440 020 | 779 536 | 331 294 | 275 917 | 1 826 727 |
| 1966 | 442 447 | 729 148 | 292 223 | 164 253 | 1 628 071 |
| 1967 | 391 347 | 947 955 | 230 182 | 120 350 | 1 689 834 |
| 1968 | 375 263 | 935 716 | 198 038 | 56 780 | 1 565 797 |
| 1969 | 274 410 | 923 452 | 197 670 | 109 592 | 1 505 124 |
| 1970 | 214 717 | 1 132 915 | 375 019 | 99 373 | 1 822 024 |
| 1971 | 193 291 | 1 089 103 | 308 798 | 83 851 | 1 675 043 |
| 1972 | 229 771 | 967 640 | 240 195 | 50 225 | 1 487 831 |
| 1973 | 243 708 | 713 134 | 185 946 | 57 730 | 1 200 518 |
| 1974 | 250 248 | 798 564 | 197 322 | 83 484 | 1 329 618 |
| 1975 | 216 158 | 532 991 | 184 203 | 97 971 | 1 031 323 |
| 1976 | 156 030 | 507 620 | 166 366 | 97 735 | 927 751 |
| 1977 | 175 643 | 515 780 | 213 279 | 124 329 | 1 029 031 |
| 1978 | 209 335 | 227 065 | 490 489 | 135 197 | 1 181 743 |
| 1979 | 198 955 | 437 562 | 131 032 | 150 018 | 917 567 |
| 1980 | 187 635 | 566 610 | 259 877 | 173 945 | 1 188 067 |
| 1981 | 306 197 | 675 712 | 478 754 | 170 369 | 1 631 032 |
| 1982 | 288 421 | 386 940 | 424 218 | 164 742 | 1 264 321 |

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[1] Includes iron, titanium, uranium, molybdenum and other metal deposits.

## TABLE 60. CANADA, EXPLORATION DIAMOND DRILLING, METAL DEPOSITS, 1953-82

| | Mining Companies With Own Personnel and Equipment | Diamond Drill Contractors | Total |
|---|---|---|---|
| | | (metres) | |
| 1953 | 318 970 | 872 668 | 1 191 638 |
| 1954 | 295 613 | 1 109 844 | 1 405 457 |
| 1955 | 464 118 | 1 546 025 | 2 010 143 |
| 1956 | 474 562 | 1 644 735 | 2 119 297 |
| 1957 | 358 300 | 1 233 323 | 1 591 623 |
| 1958 | 237 133 | 1 200 625 | 1 437 758 |
| 1959 | 239 786 | 1 367 061 | 1 606 847 |
| 1960 | 268 381 | 1 409 416 | 1 677 797 |
| 1961 | 302 696 | 1 337 173 | 1 639 869 |
| 1962 | 167 214 | 1 748 023 | 1 915 237 |
| 1963 | 361 180 | 1 169 292 | 1 530 472 |
| 1964 | 143 013 | 1 072 985 | 1 215 998 |
| 1965 | 209 002 | 1 176 996 | 1 385 998 |
| 1966 | 163 379 | 1 044 860 | 1 208 239 |
| 1967 | 93 164 | 1 123 137 | 1 216 301 |
| 1968 | 159 341 | 990 690 | 1 150 031 |
| 1969 | 135 311 | 1 072 328 | 1 207 639 |
| 1970 | 62 147 | 1 228 061 | 1 290 208 |
| 1971 | 86 838 | 1 053 330 | 1 140 168 |
| 1972 | 251 651 | 839 753 | 1 091 404 |
| 1973 | 321 333 | 742 899 | 1 064 232 |
| 1974 | 357 823 | 892 557 | 1 250 380 |
| 1975 | 346 770 | 618 161 | 964 931 |
| 1976 | 335 919 | 532 036 | 867 955 |
| 1977 | 327 241 | 638 327 | 965 568 |
| 1978 | 237 250 | 534 557 | 771 807 |
| 1979 | 311 221 | 571 721 | 882 942 |
| 1980 | 347 829 | 747 566 | 1 095 395 |
| 1981 | 460 687 | 917 566 | 1 378 253 |
| 1982 | 289 901 | 713 413 | 1 003 314 |

## TABLE 61. CANADA, DIAMOND DRILLING, OTHER THAN FOR EXPLORATION, METAL DEPOSITS, 1953-82

| | Mining Companies With Own Personnel and Equipment | Diamond Drill Contractors | Total |
|---|---|---|---|
| | (metres) | | |
| 1953 | .. | .. | 893 617 |
| 1954 | .. | .. | 629 067 |
| 1955 | 410 925 | 52 017 | 462 942 |
| 1956 | 790 522 | 46 188 | 836 710 |
| 1957 | 524 724 | 156 060 | 680 784 |
| 1958 | 444 376 | 172 516 | 616 892 |
| 1959 | 488 783 | 238 753 | 727 536 |
| 1960 | 450 246 | 308 860 | 759 105 |
| 1961 | 384 432 | 175 149 | 559 581 |
| 1962 | 528 700 | 192 259 | 720 959 |
| 1963 | 388 228 | 25 422 | 413 650 |
| 1964 | 385 765 | 72 594 | 458 359 |
| 1965 | 393 947 | 46 822 | 440 769 |
| 1966 | 227 968 | 191 863 | 419 831 |
| 1967 | 186 463 | 287 071 | 473 534 |
| 1968 | 122 851 | 292 914 | 415 765 |
| 1969 | 87 552 | 209 933 | 297 485 |
| 1970 | 290 363 | 241 453 | 531 816 |
| 1971 | 295 966 | 238 910 | 534 876 |
| 1972 | 304 523 | 91 903 | 396 426 |
| 1973 | 77 162 | 59 124 | 136 286 |
| 1974 | 54 353 | 24 885 | 79 238 |
| 1975 | 31 917 | 34 475 | 66 392 |
| 1976 | 31 413 | 28 383 | 59 796 |
| 1977 | 24 303 | 39 160 | 63 463 |
| 1978 | 351 344 | 58 592 | 409 936 |
| 1979 | 4 090 | 30 535 | 34 625 |
| 1980 | 20 545 | 72 127 | 92 672 |
| 1981 | 200 898 | 51 881 | 252 779 |
| 1982 | 188 674 | 72 333 | 261 007 |

Nonproducing companies excluded since 1964.
.. Not available.

## TABLE 62. CANADA, CRUDE MINERALS TRANSPORTED BY CANADIAN RAILWAYS, 1980-82

| | 1980 | 1981 | 1982 |
|---|---|---|---|
| | | (000 tonnes) | |
| **Metallic minerals** | | | |
| Alumina and bauxite | 2 752 | 3 133 | 2 793 |
| Copper ores and concentrates | 1 546 | 1 624 | 1 507 |
| Iron ores and concentrates | 54 167 | 49 788 | 35 101 |
| Iron pyrite | 46 | 30 | 295 |
| Lead ores and concentrates | 515 | 511 | 545 |
| Lead-zinc ores and concentrates | 353 | 3 | 1 |
| Manganese ores | 7 | 8 | 5 |
| Nickel-copper ores and concentrates | 4 983 | 4 457 | 1 890 |
| Nickel ores and concentrates | 628 | 612 | 228 |
| Tungsten ores and concentrates | 2 | 2 | 4 |
| Zinc ores an concentrates | 1 442 | 1 630 | 1 638 |
| Metallic ores and concentrates, nes | 32 | 29 | 40 |
| Total metallic minerals | 66 473 | 61 827 | 44 047 |
| **Nonmetallic minerals** | | | |
| Abrasives, natural | 70 | 61 | 37 |
| Asbestos | 400 | 332 | 190 |
| Barite | 133 | 72 | 21 |
| Clay | 621 | 606 | 485 |
| Gravel | 13 | 7 | 4 |
| Gypsum | 4 652 | 4 767 | 3 591 |
| Limestone, agricultural | 72 | 61 | 42 |
| Limestone, industrial | 331 | 299 | 177 |
| Limestone, nes | 3 801 | 4 139 | 3 049 |
| Nepheline syenite | 340 | 340 | 274 |
| Phosphate rock | 2 912 | 2 572 | 1 665 |
| Potash (KCl) | 10 652 | 9 703 | 7 681 |
| Refractory materials, nes | 4 | 4 | 3 |
| Salt, rock | 1 015 | 909 | 1 078 |
| Salt, nes | 120 | 102 | 83 |
| Sand, industrial | 1 105 | 986 | 743 |
| Sand, nes | 13 | 11 | 10 |
| Silica | 33 | 16 | 12 |
| Sodium carbonate | 581 | 552 | 481 |
| Sodium sulphate | 547 | 600 | 623 |
| Stone, building, rough | 62 | 9 | 6 |
| Stone, nes | 236 | 185 | 87 |
| Sulphur, liquid | 1 750 | 1 905 | 1 518 |
| Sulphur, nes | 5 728 | 5 931 | 4 855 |
| Nonmetallic minerals, nes | 178 | 221 | 145 |
| Total nonmetallic minerals | 35 369 | 34 390 | 26 860 |
| **Mineral fuels** | | | |
| Coal, anthracite | 125 | 69 | 56 |
| Coal, bituminous | 22 177 | 23 054 | 23 293 |
| Coal, lignite | 486 | 1 148 | 1 312 |
| Coal, nes | 18 | 21 | 12 |
| Natural gas and other crude bituminous substances | 4 | 4 | 7 |
| Oil, crude | 172 | 163 | 91 |
| Total mineral fuels | 22 982 | 24 459 | 24 771 |
| Total crude minerals | 124 824 | 120 676 | 95 678 |
| Total revenue freight moved by Canadian railways | 254 447 | 246 643 | 212 542 |
| Per cent crude minerals of total revenue freight | 49.1 | 48.9 | 45.0 |

nes Not elsewhere specified.

## TABLE 63. CANADA, FABRICATED MINERAL PRODUCTS TRANSPORTED BY CANADIAN RAILWAYS, 1980-82

| | 1980 | 1981 | 1982 |
|---|---|---|---|
| | (000 tonnes) | | |
| **Metallic mineral products** | | | |
| Ferrous mineral products | | | |
| Ferroalloys | 75 | 102 | 47 |
| Pig iron | 80 | 134 | 42 |
| Ingots, blooms, billets, slabs of iron and steel | 425 | 933 | 630 |
| Other primary iron and steel | 64 | 210 | 21 |
| Castings and forgings, iron and steel | 198 | 179 | 114 |
| Bars and rods, steel | 728 | 825 | 521 |
| Plates, steel | 553 | 590 | 314 |
| Sheet and strip, steel | 992 | 1 016 | 666 |
| Structural shapes and sheet piling, iron and steel | 445 | 467 | 216 |
| Rails and railway track material | 101 | 131 | 94 |
| Pipes and tubes, iron and steel | 546 | 767 | 448 |
| Wire, iron or steel | 39 | 29 | 21 |
| Iron and steel scrap | 2 087 | 1 806 | 1 162 |
| Slag, dross, etc. | 128 | 162 | 52 |
| Total ferrous mineral products | 6 461 | 7 351 | 4 348 |
| Nonferrous mineral products | | | |
| Aluminum paste, powder, pigs, ingots, shot | 128 | 115 | 291 |
| Aluminum and aluminum alloy fabricated material, nes | 230 | 229 | 234 |
| Copper matte and precipitates | 3 | 1 | 351 |
| Copper and alloys, in primary form | 389 | 379 | 327 |
| Copper and alloys, nes | 58 | 44 | 23 |
| Lead and alloys | 128 | 126 | 119 |
| Nickel and nickel-copper matte | 96 | 94 | 46 |
| Nickel and alloys | 30 | 35 | 15 |
| Zinc and alloys | 447 | 453 | 406 |
| Other nonferrous base metals and alloys | 29 | 19 | 13 |
| Nonferrous metal scrap | 103 | 60 | 48 |
| Total nonferrous mineral products | 1 641 | 1 555 | 1 873 |
| Total metallic mineral products | 8 102 | 8 906 | 6 221 |
| **Nonmetallic mineral products** | | | |
| Natural stone basic products, chiefly structural | 227 | 196 | 160 |
| Bricks and tiles, clay | 45 | 46 | 20 |
| Fire brick and similar shapes | 111 | 86 | 47 |
| Dolomite and magnesite, calcined | 85 | 71 | 39 |
| Refractories, nes | 36 | 33 | 16 |
| Glass basic products | 102 | 91 | 84 |
| Asbestos and asbestos-cement basic products | 33 | 36 | 23 |
| Portland cement, standard | 1 763 | 1 804 | 1 349 |
| Concrete pipe | 20 | 10 | 4 |
| Cement and concrete basic products, nes | 324 | 333 | 169 |
| Plaster | 21 | 18 | 13 |
| Gypsum wallboard and sheathing | 22 | 25 | 14 |
| Gypsum basic products, nes | 3 | 7 | 7 |
| Lime, hydrated and quick | 303 | 219 | 186 |
| Nonmetallic mineral basic products, nes | 458 | 424 | 299 |
| Fertilizers and fertilizer materials, nes | 2 092 | 1 937 | 1 581 |
| Total nonmetallic mineral products | 5 645 | 5 336 | 4 011 |

(continued on following page)

TABLE 63. (cont'd)

|  | 1980 | 1981 | 1982 |
|---|---|---|---|
|  | (000 tonnes) |  |  |
| **Mineral fuel products** |  |  |  |
| Gasoline | 1 455 | 1 511 | 1 376 |
| Aviation turbine fuel | 54 | 63 | 32 |
| Diesel fuel | 2 898 | 2 778 | 2 223 |
| Kerosene | 1 | 1 | 2 |
| Fuel oil, nes | 1 000 | 1 080 | 890 |
| Lubricating oils and greases | 389 | 342 | 296 |
| Petroleum coke | 626 | 463 | 537 |
| Coke, nes | 708 | 701 | 567 |
| Refined and manufactured gases, fuel type | 2 737 | 3 010 | 2 991 |
| Asphalts and road oils | 187 | 214 | 256 |
| Bituminous pressed or molded fabricated material | 1 | 1 | 1 |
| Other petroleum and coal products | 747 | 766 | 641 |
| Total mineral fuel products | 10 803 | 10 930 | 9 812 |
| Total fabricated mineral products | 24 550 | 25 172 | 20 044 |
| Total revenue freight moved by Canadian railways | 254 447 | 246 643 | 212 542 |
| Fabricated mineral products as a percentage of total revenue freight | 9.6 | 10.2 | 9.4 |

nes Not elsewhere specified.

## TABLE 64. CANADA, CRUDE AND FABRICATED MINERALS TRANSPORTED BY CANADIAN RAILWAYS, 1953-82

| | Total Revenue Freight | Total Crude Minerals | Total Fabricated Minerals | Total Crude and Fabricated Minerals | Crude and Fabricated Minerals as % of Revenue Freight |
|---|---|---|---|---|---|
| | | | (million tonnes) | | |
| 1953 | 141.7 | 44.7 | 16.4 | 61.1 | 43.1 |
| 1954 | 129.8 | 45.0 | 16.8 | 61.8 | 47.6 |
| 1955 | 152.2 | 61.2 | 19.0 | 80.2 | 52.7 |
| 1956 | 172.0 | 68.7 | 21.8 | 90.5 | 52.6 |
| 1957 | 157.9 | 64.2 | 17.1 | 81.3 | 51.5 |
| 1958 | 139.2 | 52.4 | 15.2 | 67.6 | 48.6 |
| 1959 | 150.6 | 62.8 | 15.3 | 78.1 | 52.9 |
| 1960 | 142.8 | 57.1 | 14.5 | 71.6 | 50.1 |
| 1961 | 138.9 | 54.1 | 13.6 | 67.7 | 48.7 |
| 1962 | 146.0 | 60.3 | 13.8 | 74.1 | 50.8 |
| 1963 | 154.6 | 62.9 | 15.5 | 78.3 | 50.6 |
| 1964 | 180.0 | 74.6 | 15.9 | 90.5 | 50.3 |
| 1965 | 186.2 | 80.9 | 17.3 | 98.2 | 52.7 |
| 1966 | 194.5 | 80.6 | 17.8 | 98.4 | 50.6 |
| 1967 | 190.0 | 81.2 | 17.7 | 98.9 | 52.1 |
| 1968 | 195.4 | 86.7 | 18.8 | 105.5 | 54.0 |
| 1969 | 189.0 | 81.9 | 27.6 | 109.5 | 57.9 |
| 1970 | 211.6 | 97.5 | 28.4 | 127.9 | 60.4 |
| 1971 | 214.5 | 95.6 | 27.4 | 123.0 | 57.3 |
| 1972 | 215.8 | 89.4 | 27.6 | 117.0 | 54.2 |
| 1973 | 241.2 | 113.1 | 29.1 | 142.2 | 59.0 |
| 1974 | 246.3 | 115.3 | 30.9 | 146.2 | 59.4 |
| 1975 | 226.0 | 110.6 | 26.6 | 137.2 | 60.7 |
| 1976 | 238.5 | 116.6 | 25.5 | 142.1 | 59.6 |
| 1977 | 247.2 | 121.1 | 25.7 | 146.8 | 59.4 |
| 1978 | 238.8 | 107.7 | 26.2 | 133.9 | 45.1 |
| 1979 | 257.9 | 127.2 | 26.6 | 153.8 | 59.6 |
| 1980 | 254.4 | 124.8 | 24.6 | 149.4 | 58.8 |
| 1981 | 246.6 | 120.7 | 25.2 | 145.9 | 59.2 |
| 1982 | 212.5 | 95.7 | 20.0 | 115.7 | 54.4 |

TABLE 65. CANADA, CRUDE AND FABRICATED MINERALS TRANSPORTED THROUGH THE ST. LAWRENCE SEAWAY, 1981-83

| | Montreal-Lake Ontario Section | | | Welland Canal Section | | |
|---|---|---|---|---|---|---|
| | 1981 | 1982 | 1983 | 1981 | 1982 | 1983 |
| | (tonnes) | | | | | |
| **Crude minerals** | | | | | | |
| Coal | 1 519 188 | 1 046 580 | 350 170 | 5 935 727 | 6 478 426 | 5 494 597 |
| Iron ore | 11 727 044 | 6 740 758 | 10 280 210 | 12 468 808 | 6 364 815 | 9 229 290 |
| Aluminum ores and concentrates | 149 932 | 96 024 | 115 345 | 144 525 | 96 024 | 115 345 |
| Clay and bentonite | 180 280 | 129 267 | 76 849 | 180 280 | 129 266 | 76 849 |
| Gravel and sand | 36 651 | 33 | 7 975 | 203 970 | 118 341 | 203 063 |
| Stone, ground or crushed | 23 036 | 30 839 | 47 462 | 952 603 | 102 695 | 401 719 |
| Stone, rough | 122 | 2 025 | 292 | 122 | 2 026 | 289 |
| Salt | 1 029 608 | 648 547 | 878 535 | 1 599 337 | 1 287 540 | 1 455 070 |
| Phosphate rock | 27 432 | - | 35 156 | - | - | 16 326 |
| Sulphur | 25 615 | 2 733 | - | 25 613 | 2 733 | - |
| Other crude minerals | 706 831 | 449 397 | 651 140 | 620 819 | 475 377 | 419 199 |
| Total crude minerals | 15 452 739 | 9 146 203 | 12 443 134 | 22 131 804 | 15 057 243 | 17 411 747 |
| **Fabricated mineral products** | | | | | | |
| Coke | 773 992 | 617 617 | 638 042 | 880 911 | 686 590 | 683 081 |
| Gasoline | 112 348 | 144 035 | 249 993 | 136 566 | 157 842 | 218 092 |
| Fuel oil | 1 667 865 | 909 030 | 936 121 | 1 652 474 | 972 930 | 835 488 |
| Lubricating oils and greases | 64 677 | 44 330 | 13 070 | 51 026 | 34 414 | 12 889 |
| Other petroleum products | 151 924 | 157 202 | 110 029 | 111 501 | 139 305 | 116 155 |
| Tar, pitch and creosote | 39 613 | 38 236 | 25 154 | 37 482 | 45 328 | 43 015 |
| Pig iron | 183 752 | 138 048 | 161 017 | 173 884 | 128 814 | 150 896 |
| Iron and steel: bars, rods, slabs | 314 656 | 103 714 | 286 838 | 299 479 | 99 304 | 361 841 |
| Iron and steel: nails, wire | 7 364 | 15 005 | 4 184 | 6 949 | 10 705 | 3 305 |
| Iron and steel: manufactured | 2 313 521 | 2 412 338 | 2 605 115 | 1 861 767 | 1 459 619 | 2 416 949 |
| Scrap iron and steel | 79 254 | 414 788 | 390 006 | 57 564 | 382 445 | 366 974 |
| Cement | 2 512 | 3 129 | 2 522 | 259 002 | 215 523 | 409 794 |
| Total fabricated minerals | 5 711 478 | 4 997 472 | 5 422 091 | 5 528 605 | 4 332 819 | 5 618 479 |
| Total crude and fabricated minerals | 21 137 217 | 14 143 675 | 17 865 225 | 27 660 409 | 19 390 062 | 23 030 226 |
| Total all products | 45 875 658 | 38 841 399 | 45 060 981 | 53 388 616 | 44 473 919 | 50 145 086 |
| Crude and fabricated minerals as a per cent of total | 46.1 | 36.4 | 39.6 | 51.8 | 43.6 | 45.9 |

- Nil.

TABLE 66. CANADA, CRUDE AND FABRICATED MINERALS TRANSPORTED THROUGH THE ST. LAWRENCE SEAWAY, 1954-83

| | Montreal - Lake Ontario Section | | | | Welland Canal Section | | | |
|---|---|---|---|---|---|---|---|---|
| | Total All Products | Total Crude Minerals | Total Fabricated Minerals | Crude and Fabricated Minerals as % of All Products | Total All Products | Total Crude Minerals | Total Fabricated Minerals | Crude and Fabricated Minerals as % of All Products |
| | (kilotonnes) | | | | (kilotonnes) | | | |
| 1954 | 8 742 | 1 920 | 1 077 | 34.3 | 15 888 | 6 996 | 2 308 | 58.6 |
| 1955 | 10 384 | 3 859 | 1 244 | 49.1 | 18 954 | 10 257 | 2 097 | 65.2 |
| 1956 | 12 247 | 4 807 | 1 314 | 50.0 | 20 925 | 11 405 | 2 169 | 64.8 |
| 1957 | 11 059 | 4 439 | 1 392 | 52.7 | 20 296 | 11 305 | 2 421 | 67.6 |
| 1958 | 10 670 | 3 064 | 1 020 | 38.3 | 19 300 | 8 994 | 2 107 | 57.5 |
| 1959 | 19 252 | 7 725 | 2 197 | 51.5 | 24 953 | 12 117 | 2 246 | 57.6 |
| 1960 | 18 460 | 5 760 | 2 904 | 46.9 | 26 563 | 12 679 | 2 606 | 57.5 |
| 1961 | 21 212 | 6 706 | 2 358 | 42.7 | 28 490 | 12 599 | 2 378 | 52.7 |
| 1962 | 23 271 | 7 531 | 2 522 | 43.2 | 32 215 | 15 625 | 2 342 | 55.8 |
| 1963 | 28 198 | 9 507 | 2 804 | 43.7 | 37 490 | 18 094 | 2 524 | 55.0 |
| 1964 | 35 701 | 13 127 | 3 558 | 46.7 | 46 644 | 23 489 | 3 095 | 57.0 |
| 1965 | 39 352 | 13 788 | 6 024 | 50.3 | 48 477 | 23 555 | 4 933 | 58.8 |
| 1966 | 44 538 | 16 376 | 6 340 | 51.0 | 53 648 | 25 712 | 5 329 | 57.8 |
| 1967 | 39 918 | 17 800 | 6 430 | 60.7 | 47 945 | 26 010 | 5 459 | 65.6 |
| 1968 | 43 496 | 19 312 | 8 425 | 63.8 | 52 712 | 29 075 | 7 587 | 69.6 |
| 1969 | 37 256 | 12 682 | 8 263 | 56.2 | 48 601 | 25 090 | 6 715 | 65.4 |
| 1970 | 46 445 | 15 554 | 8 932 | 52.7 | 57 121 | 27 233 | 7 156 | 60.2 |
| 1971 | 48 069 | 14 204 | 9 263 | 48.8 | 57 205 | 23 903 | 7 914 | 55.6 |
| 1972 | 48 607 | 13 425 | 9 837 | 47.9 | 58 146 | 24 808 | 7 701 | 55.9 |
| 1973 | 52 285 | 17 111 | 9 639 | 51.1 | 60 958 | 26 907 | 7 718 | 56.8 |
| 1974 | 40 049 | 16 137 | 7 018 | 57.8 | 47 500 | 23 952 | 5 437 | 61.9 |
| 1975 | 43 554 | 15 698 | 6 071 | 50.0 | 53 387 | 26 100 | 5 129 | 58.5 |
| 1976 | 49 348 | 20 884 | 7 181 | 56.9 | 58 368 | 29 914 | 6 323 | 62.1 |
| 1977 | 57 456 | 23 008 | 9 918 | 57.3 | 65 079 | 30 459 | 8 933 | 60.5 |
| 1978 | 51 658 | 15 057 | 8 558 | 45.7 | 59 576 | 22 700 | 7 759 | 51.1 |
| 1979 | 50 187 | 16 408 | 8 104 | 48.8 | 60 023 | 24 851 | 7 940 | 54.6 |
| 1980 | 42 142 | 12 248 | 6 009 | 43.3 | 54 074 | 20 487 | 5 405 | 47.9 |
| 1981 | 45 876 | 15 453 | 5 711 | 46.1 | 53 389 | 22 132 | 5 529 | 51.8 |
| 1982 | 38 841 | 9 146 | 4 997 | 36.4 | 44 474 | 15 057 | 4 333 | 45.9 |
| 1983 | 45 061 | 12 443 | 5 422 | 39.6 | 50 145 | 17 412 | 5 618 | 45.9 |

TABLE 67. CANADA, CRUDE MINERALS LOADED AND UNLOADED IN COASTWISE SHIPPING, 1982

| | Loaded | | | | Unloaded | | | |
|---|---|---|---|---|---|---|---|---|
| | Atlantic | Great Lakes | Pacific | Total | Atlantic | Great Lakes | Pacific | Total |
| | (tonnes) | | | | | | | |
| **Metallic minerals** | | | | | | | | |
| Copper ore and concentrates | 17 786 | - | - | 17 786 | 17 786 | - | - | 17 786 |
| Iron ore and concentrates | 3 036 890 | 812 385 | - | 3 849 275 | 772 198 | 3 077 077 | - | 3 849 275 |
| Titanium ore | 1 497 413 | - | - | 1 497 413 | 1 497 413 | - | - | 1 497 413 |
| Zinc ore and concentrates | - | - | 20 838 | 20 838 | - | - | 20 838 | 20 838 |
| Total metals | 4 552 089 | 812 385 | 20 838 | 5 385 312 | 2 287 397 | 3 077 077 | 20 838 | 5 385 312 |
| **Nonmetallic minerals** | | | | | | | | |
| Dolomite | - | 31 433 | - | 31 433 | 31 433 | - | - | 31 433 |
| Gypsum | 345 175 | - | 21 562 | 366 737 | 281 395 | 63 780 | 21 562 | 366 737 |
| Limestone | 4 325 | 1 451 063 | 803 220 | 2 258 608 | 19 321 | 1 436 067 | 803 220 | 2 258 608 |
| Potash | 59 | 203 932 | - | 203 991 | 59 | 203 932 | - | 203 991 |
| Salt | 476 852 | 940 630 | 41 769 | 1 459 251 | 1 019 669 | 397 813 | 41 769 | 1 459 251 |
| Sand and gravel | 104 289 | - | 2 705 725 | 2 810 014 | 104 289 | - | 2 705 725 | 2 810 014 |
| Stone, crude, nes | 23 263 | 336 143 | 119 874 | 479 280 | 509 | 358 897 | 119 874 | 479 280 |
| Sulphur in ores | 8 019 | - | 4 659 | 12 678 | 8 019 | - | 4 659 | 12 678 |
| Crude nonmetallic minerals, nes | 5 036 | - | 316 | 5 352 | 5 036 | - | 316 | 5 352 |
| Total nonmetals | 967 018 | 2 963 201 | 3 697 125 | 7 627 344 | 1 469 730 | 2 460 489 | 3 697 125 | 7 627 344 |
| **Mineral fuels** | | | | | | | | |
| Coal, bituminous | 58 085 | 2 099 383 | - | 2 157 468 | 58 085 | 2 099 383 | - | 2 157 468 |
| Petroleum, crude | 1 303 155 | - | - | 1 303 155 | 1 303 155 | - | - | 1 303 155 |
| Total mineral fuels | 1 361 240 | 2 099 383 | - | 3 460 623 | 1 361 240 | 2 099 383 | - | 3 460 623 |
| Total crude minerals | 6 880 347 | 5 874 969 | 3 717 963 | 16 473 279 | 5 118 367 | 7 636 949 | 3 717 963 | 16 473 279 |
| Total all commodities | 16 860 211 | 25 600 810 | 23 420 561 | 65 881 582 | 30 081 985 | 12 425 200 | 23 374 397 | 65 881 582 |
| Crude minerals as a per cent of all commodities | 40.8 | 22.9 | 15.9 | 25.0 | 17.0 | 61.5 | 15.9 | 25.0 |

- Nil; nes Not elsewhere specified.

## TABLE 68. CANADA, FABRICATED MINERALS LOADED AND UNLOADED IN COASTWISE SHIPPING, 1982

| | Loaded | | | | Unloaded | | | |
|---|---|---|---|---|---|---|---|---|
| | Atlantic | Great Lakes | Pacific | Total | Atlantic | Great Lakes | Pacific | Total |
| | | | | (tonnes) | | | | |
| **Metallic mineral products** | | | | | | | | |
| Ferrous mineral products | | | | | | | | |
| Primary iron, steel | 6 915 | 3 831 | - | 10 746 | 36 | 10 710 | - | 10 746 |
| Castings and forgings, steel | 3 161 | 900 | 4 069 | 8 130 | 4 061 | - | 4 069 | 8 130 |
| Bars and rods, steel | 3 491 | 6 616 | - | 10 107 | 3 491 | 6 616 | - | 10 107 |
| Plates and sheets, steel | 6 912 | 16 371 | - | 23 283 | 6 912 | 16 371 | - | 23 283 |
| Structual shapes, iron and steel | 18 037 | 14 018 | 2 096 | 34 151 | 18 037 | 14 018 | 2 096 | 34 151 |
| Rails and railway track material | 2 513 | - | - | 2 513 | 2 513 | - | - | 2 513 |
| Pipes and tubes, iron and steel | 4 512 | - | 771 | 5 283 | 4 512 | - | 771 | 5 283 |
| Wire, iron and steel | 649 | - | 36 | 685 | 649 | - | 36 | 685 |
| Iron and steel scrap | 129 | - | 1 226 | 1 355 | 129 | - | 1 226 | 1 355 |
| Total ferrous mineral products | 46 319 | 41 736 | 8 198 | 96 253 | 40 340 | 47 715 | 8 198 | 96 253 |
| Nonferrous mineral products | | | | | | | | |
| Aluminum and aluminum products | 64 550 | - | - | 65 550 | 64 550 | - | - | 64 550 |
| Copper and alloys | 5 | - | - | 5 | 5 | - | - | 5 |
| Nickel and alloys | 38 | - | - | 38 | 38 | - | - | 38 |
| Other nonferrous metals and alloys | 6 049 | - | - | 6 049 | 5 691 | 358 | - | 6 049 |
| Nonferrous metal scrap | 1 845 | - | - | 1 845 | 1 845 | - | - | 1 845 |
| Total nonferrous mineral products | 72 487 | - | - | 72 487 | 72 129 | 358 | - | 72 487 |
| Total metallic mineral products | 118 806 | 41 736 | 8 198 | 168 740 | 112 469 | 48 073 | 8 198 | 168 740 |
| **Nonmetallic mineral products** | | | | | | | | |
| Asbestos basic products | 62 | - | - | 62 | 62 | - | - | 62 |
| Bricks, tiles and pipes, clay | 4 401 | - | - | 4 401 | 4 401 | - | - | 4 401 |
| Cement | 8 598 | 407 184 | 173 055 | 588 837 | 8 598 | 407 184 | 173 055 | 588 837 |
| Cement basic products | 2 535 | - | 1 362 | 3 897 | 2 535 | - | 1 362 | 3 897 |
| Fertilizers and fertilizer material nes | 15 205 | - | 5 038 | 20 243 | 7 789 | 7 416 | 5 038 | 20 243 |
| Glass basic products | 181 | - | - | 181 | 181 | - | - | 181 |
| Lime, quick and hydrated | 3 218 | - | 7 510 | 10 728 | 3 218 | - | 7 510 | 10 728 |
| Sulphur acid | 42 926 | - | 18 136 | 61 062 | 6 360 | 36 566 | 18 136 | 61 062 |
| Other nonmetallic mineral products | 4 472 | - | - | 4 472 | 4 472 | - | - | 4 472 |
| Total nonmetallic mineral products | 81 598 | 407 184 | 205 101 | 693 883 | 37 616 | 451 166 | 205 101 | 693 883 |
| **Mineral fuel products** | | | | | | | | |
| Asphalts and road oils | 48 883 | - | 26 160 | 75 043 | 37 802 | 11 081 | 26 160 | 75 043 |
| Fuel oil | 5 463 014 | 1 815 151 | 1 154 014 | 8 432 179 | 6 242 017 | 1 064 740 | 1 125 422 | 8 432 179 |
| Gasoline | 2 440 035 | 639 622 | 630 542 | 3 710 199 | 2 532 560 | 546 997 | 630 542 | 3 710 199 |
| Lubricating oils and greases | 27 929 | 9 498 | - | 37 427 | 12 773 | 24 654 | - | 37 427 |
| Petroleum coke | 16 690 | 14 384 | - | 31 074 | 31 074 | - | - | 31 074 |
| Other petroleum and coal products | 13 338 | 52 319 | - | 65 657 | 37 296 | 28 361 | - | 65 657 |
| Total mineral fuel products | 8 009 889 | 2 530 974 | 1 810 716 | 12 351 579 | 8 893 622 | 1 675 833 | 1 782 124 | 12 351 579 |
| Total fabricated mineral products | 8 210 293 | 2 979 894 | 2 024 015 | 13 214 202 | 9 043 707 | 2 175 072 | 1 995 423 | 13 214 202 |
| Total all commodities | 16 860 211 | 25 600 810 | 23 420 561 | 65 881 582 | 30 081 985 | 12 425 200 | 23 374 397 | 65 881 582 |
| Fabricated mineral products as a per cent of all commodities | 48.7 | 11.6 | 8.6 | 20.1 | 30.0 | 17.5 | 8.5 | 20.1 |

- Nil; nes Not elsewhere specified.

## TABLE 69. CANADA, CRUDE AND FABRICATED MINERALS LOADED AT CANADIAN PORTS IN COASTWISE SHIPPING; 1953-82

| | Total All Commodities | Total Crude Minerals | Total Fabricated Minerals | Crude and Fabricated Minerals as % of All Products |
|---|---|---|---|---|
| | | (kilotonnes) | | |
| 1953 | 25 922 | 4 271 | 5 449 | 37.5 |
| 1954 | 23 402 | 4 101 | 5 552 | 41 2 |
| 1955 | 25 050 | 4 371 | 6 229 | 42.3 |
| 1956 | 31 303 | 6 750 | 7 275 | 44.8 |
| 1957 | 34 354 | 8 696 | 7 832 | 48.1 |
| 1958 | 34 808 | 7 673 | 7 258 | 42.9 |
| 1959 | 36 494 | 9 984 | 7 819 | 48.8 |
| 1960 | 37 058 | 8 786 | 8 229 | 45.9 |
| 1961 | 41 861 | 9 527 | 8 857 | 43.9 |
| 1962 | 39 763 | 8 361 | 9 768 | 45.6 |
| 1963 | 40 328 | 7 998 | 9 942 | 44.5 |
| 1964 | 47 171 | 8 522 | 11 194 | 41.8 |
| 1965 | 48 200 | 9 183 | 11 766 | 43.5 |
| 1966 | 55 122 | 10 155 | 12 653 | 41.4 |
| 1967 | 49 799 | 11 509 | 12 207 | 47.6 |
| 1968 | 50 921 | 13 698 | 13 245 | 52.9 |
| 1969 | 51 890 | 12 746 | 14 181 | 51.9 |
| 1970 | 57 301 | 14 415 | 14 818 | 51.0 |
| 1971 | 55 128 | 14 783 | 15 374 | 54.7 |
| 1972 | 55 326 | 14 197 | 15 290 | 53.3 |
| 1973 | 55 314 | 16 573 | 15 615 | 58.2 |
| 1974 | 53 633 | 11 723 | 16 575 | 52.8 |
| 1975 | 54 373 | 15 687 | 17 510 | 61.1 |
| 1976 | 53 882 | 15 924 | 16 208 | 59.6 |
| 1977 | 58 309 | 18 131 | 17 435 | 61.0 |
| 1978 | 60 668 | 18 318 | 16 619 | 57.6 |
| 1979 | 79 950 | 22 130 | 17 486 | 50.2 |
| 1980 | 82 761 | 22 947 | 17 134 | 48.4 |
| 1981 | 71 271 | 17 849 | 16 669 | 48.4 |
| 1982 | 65 881 | 16 473 | 13 214 | 45.1 |

## TABLE 70. CANADA, CRUDE MINERALS LOADED AND UNLOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1980-82

| | 1980 | | 1981 | | 1982 | |
|---|---|---|---|---|---|---|
| | Loaded | Unloaded | Loaded | Unloaded | Loaded | Unloaded |
| | (tonnes) | | | | | |
| **Metallic minerals** | | | | | | |
| Alumina, bauxite ore | 15 945 | 3 934 926 | 6 595 | 3 886 501 | 7 336 | 3 367 797 |
| Copper ores and concentrates | 587 352 | 26 223 | 1 034 946 | 78 240 | 1 097 233 | 108 646 |
| Iron ore and concentrates | 35 594 404 | 5 209 050 | 41 909 908 | 7 713 979 | 27 770 684 | 3 322 648 |
| Lead ore and concentrates | 74 749 | 5 092 | 124 939 | 3 833 | 206 261 | 6 119 |
| Manganese ore | 19 800 | 129 682 | 25 959 | 168 395 | - | 165 332 |
| Nickel ore and concentrates | 71 262 | 1 463 | 85 603 | 2 620 | 39 089 | 3 531 |
| Titanium ore | 130 913 | - | 855 586 | 14 936 | 845 861 | 5 518 |
| Zinc ore and concentrates | 292 799 | 524 | 728 140 | - | 940 419 | - |
| Other nonferrous ores, concentrates and metal scrap, nes | 681 518 | 611 841 | 119 493 | 107 307 | 29 311 | 31 211 |
| Total metals | 37 468 742 | 9 918 801 | 44 891 169 | 11 975 811 | 30 936 194 | 7 010 802 |
| **Nonmetallic minerals** | | | | | | |
| Asbestos | 891 831 | 10 682 | 706 622 | 25 286 | 605 982 | 25 564 |
| Barite | - | 36 | - | 8 158 | 25 | 14 573 |
| Bentonite | 14 317 | 151 649 | 4 | 176 559 | 18 | 96 908 |
| China clay | 93 | 19 059 | - | 34 693 | - | 6 409 |
| Clay materials, nes | 15 258 | 78 405 | 1 334 | 5 533 | 1 756 | 50 242 |
| Dolomite | 907 715 | 38 413 | 948 552 | - | 117 788 | 10 724 |
| Fluorspar | - | 145 838 | - | 190 592 | - | 125 789 |
| Gypsum | 4 733 725 | 175 759 | 5 062 237 | 134 252 | 4 475 409 | 80 864 |
| Limestone | 1 842 439 | 1 365 421 | 1 711 487 | 2 261 324 | 1 443 482 | 1 266 945 |
| Phosphate rock | - | 1 368 116 | - | 1 197 106 | - | 1 353 595 |
| Potash (KCl) | 3 843 013 | 32 723 | 4 253 511 | 18 | 4 103 313 | - |
| Salt | 1 879 269 | 991 855 | 1 431 460 | 1 327 244 | 1 664 815 | 1 164 624 |
| Sand and gravel | 78 678 | 804 079 | 151 833 | 1 322 115 | 98 179 | 935 763 |
| Stone, crude, nes | 235 805 | 548 113 | 95 377 | 27 290 | 17 037 | 50 911 |
| Stone, crushed | 100 974 | 330 230 | 13 442 | 62 766 | - | 5 315 |
| Sulphur | 5 011 131 | 43 550 | 5 726 661 | 3 | 4 869 230 | - |
| Crude, nonmetallic minerals, nes | 60 891 | 120 844 | 145 860 | 26 201 | 97 002 | 10 151 |
| Total nonmetals | 15 772 126 | 6 192 049 | 20 248 380 | 6 799 140 | 17 494 036 | 5 198 377 |
| **Mineral fuels** | | | | | | |
| Coal, bituminous | 13 735 346 | 15 137 034 | 17 458 453 | 16 066 286 | 17 162 442 | 15 142 357 |
| Coal, nes | 1 093 | 13 | 194 | 3 | 101 | 1 |
| Oil, crude | 920 578 | 15 198 039 | 408 408 | 14 070 091 | 891 | 8 246 236 |
| Total fuels | 14 657 017 | 30 335 086 | 17 867 055 | 30 136 380 | 17 163 434 | 23 388 594 |
| Total crude minerals | 67 897 885 | 46 445 936 | 83 006 604 | 48 911 331 | 65 593 664 | 35 597 773 |
| Total all commodities | 138 161 219 | 67 834 656 | 145 445 080 | 68 187 889 | 125 281 616 | 48 729 336 |
| Crude minerals as a per cent of all commodities | 49.1 | 68.5 | 57.1 | 71.7 | 52.4 | 73.1 |

- Nil; nes Not elsewhere specified.

TABLE 71. CANADA, FABRICATED MINERAL PRODUCTS LOADED AND UNLOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1980-82

| | 1980 | | 1981 | | 1982 | |
|---|---|---|---|---|---|---|
| | Loaded | Unloaded | Loaded | Unloaded | Loaded | Unloaded |
| | | | (tonnes) | | | |
| **Metallic products** | | | | | | |
| Aluminum | 398 230 | 174 109 | 272 585 | 47 503 | 557 593 | 42 200 |
| Copper and alloys | 480 212 | 25 843 | 224 600 | 44 540 | 157 620 | 36 606 |
| Ferroalloys | 18 426 | 28 958 | 24 858 | 50 890 | 19 764 | 19 805 |
| Iron and steel, primary | 28 884 | 53 666 | 2 737 | 29 898 | 1 002 | 7 916 |
| Iron, pig | 468 308 | 20 | 458 534 | 7 717 | 431 915 | - |
| Iron and steel, other | | | | | | |
| bars and rods | 343 034 | 103 467 | 79 921 | 199 244 | 131 415 | 127 193 |
| castings and forgings | 225 155 | 62 617 | 120 633 | 64 419 | 109 329 | 52 690 |
| pipes and tubes | 58 664 | 191 210 | 62 462 | 278 956 | 27 845 | 173 819 |
| plates and sheet | 1 438 646 | 442 783 | 191 667 | 1 282 572 | 1 013 763 | 351 119 |
| rails and track material | 99 726 | 7 028 | 97 644 | 12 433 | 42 095 | 16 105 |
| structural shapes | 97 094 | 69 109 | 24 030 | 240 887 | 38 170 | 41 690 |
| wire | 35 685 | 70 625 | 15 910 | 132 814 | 31 558 | 106 943 |
| Lead and alloys | 103 421 | 21 173 | 53 320 | 3 781 | 57 668 | 1 479 |
| Nickel and alloys | 52 520 | 12 385 | 40 847 | 7 661 | 44 979 | 5 489 |
| Zinc and alloys | 388 341 | 3 707 | 140 043 | 19 277 | 133 918 | 7 065 |
| Nonferrous metals, nes | 115 726 | 144 951 | 68 487 | 155 811 | 23 887 | 11 443 |
| Metal fabricated basic products | 470 038 | 607 827 | 56 351 | 170 980 | 72 131 | 121 232 |
| Total metals | 4 822 110 | 2 019 478 | 1 934 629 | 2 749 383 | 2 894 653 | 1 122 794 |
| **Nonmetallic products** | | | | | | |
| Asbestos basic products | 5 349 | 1 345 | 5 606 | 1 907 | 1 878 | 1 194 |
| Building blocks, nes | 38 490 | 25 126 | 31 527 | 36 057 | 18 681 | 45 736 |
| Cement | 1 704 324 | 75 130 | 1 719 170 | 130 990 | 1 187 272 | 7 599 |
| Cement basic products | 42 639 | 4 289 | 850 | 681 | 22 724 | 129 |
| Glass basic products | 32 801 | 15 773 | 35 226 | 15 631 | 30 271 | 13 131 |
| Nonmetallic mineral basic products | 45 406 | 201 882 | 54 739 | 73 732 | 61 800 | 204 060 |
| Fertilizers, nes | 148 320 | 57 843 | 138 603 | 125 364 | 71 921 | 92 572 |
| Total nonmetals | 1 869 009 | 323 545 | 1 985 721 | 384 362 | 1 394 547 | 364 421 |
| **Mineral fuel products** | | | | | | |
| Asphalts, road oils | 16 366 | 14 001 | 44 512 | 36 388 | 9 650 | 12 109 |
| Coal tar, pitch | 9 819 | 42 693 | 17 028 | 83 515 | 3 625 | 52 687 |
| Coke | 1 059 856 | 1 319 773 | 666 609 | 1 110 170 | 403 347 | 781 671 |
| Fuel oil | 2 101 989 | 2 352 355 | 3 380 547 | 1 888 349 | 1 612 410 | 1 721 714 |
| Gasoline | 1 250 230 | 221 458 | 615 796 | 63 450 | 487 160 | 41 047 |
| Lubricating oils and greases | 355 314 | 457 521 | 14 801 | 9 051 | 12 609 | 34 193 |
| Petroleum and coal products, nes | 285 609 | 242 793 | 266 081 | 47 448 | 275 031 | 106 462 |
| Total fuels | 5 079 183 | 4 650 594 | 5 005 374 | 3 238 371 | 2 803 832 | 2 749 885 |
| Total fabricated mineral products | 11 770 302 | 6 993 617 | 8 925 724 | 6 372 116 | 7 093 032 | 4 237 100 |
| Total all commodities | 138 161 219 | 67 834 656 | 145 445 080 | 68 187 889 | 125 281 616 | 48 729 336 |
| Fabricated mineral products as a per cent of all commodities | 8.5 | 10.3 | 6.1 | 9.3 | 5.7 | 8.7 |

- Nil; nes Not elsewhere specified.

## TABLE 72. CANADA, CRUDE AND FABRICATED MINERALS LOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1953-82

|  | Total All Commodities | Total Crude Minerals | Total Fabricated Minerals | Crude and Fabricated Minerals as % of All Products |
|---|---|---|---|---|
|  |  | (kilotonnes) |  |  |
| 1953 | 29 213 | 8 251 | 1 024 | 31.7 |
| 1954 | 27 878 | 9 316 | 1 108 | 37.4 |
| 1955 | 35 836 | 17 126 | 1 684 | 52.5 |
| 1956 | 44 791 | 23 284 | 1 904 | 56.2 |
| 1957 | 44 539 | 24 210 | 2 588 | 60.2 |
| 1958 | 36 559 | 16 602 | 1 642 | 49.9 |
| 1959 | 45 772 | 25 789 | 1 619 | 59.9 |
| 1960 | 45 872 | 24 671 | 2 039 | 58.2 |
| 1961 | 48 771 | 23 241 | 2 133 | 52.0 |
| 1962 | 54 676 | 30 446 | 2 296 | 59.9 |
| 1963 | 62 031 | 32 214 | 2 503 | 56.0 |
| 1964 | 75 760 | 42 087 | 2 602 | 59.0 |
| 1965 | 74 521 | 41 338 | 2 746 | 59.2 |
| 1966 | 76 192 | 41 374 | 3 350 | 58.7 |
| 1967 | 72 598 | 42 704 | 3 701 | 63.9 |
| 1968 | 78 663 | 48 680 | 2 960 | 65.6 |
| 1969 | 70 432 | 42 442 | 3 456 | 65.1 |
| 1970 | 95 807 | 55 849 | 4 965 | 63.5 |
| 1971 | 95 887 | 53 245 | 5 022 | 60.7 |
| 1972 | 98 988 | 51 912 | 9 091 | 61.6 |
| 1973 | 112 434 | 64 195 | 10 103 | 66.1 |
| 1974 | 106 110 | 64 093 | 9 041 | 68.9 |
| 1975 | 102 444 | 61 970 | 7 495 | 67.8 |
| 1976 | 114 815 | 71 527 | 6 108 | 67.6 |
| 1977 | 119 770 | 70 257 | 5 979 | 63.7 |
| 1978 | 116 522 | 62 291 | 7 556 | 59.9 |
| 1979 | 134 639 | 79 685 | 8 901 | 65.8 |
| 1980 | 138 161 | 67 898 | 11 770 | 57.7 |
| 1981 | 145 445 | 83 007 | 8 926 | 63.2 |
| 1982 | 125 282 | 65 594 | 7 093 | 58.1 |

## TABLE 73. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN THE MINING INDUSTRY[1], BY DEGREE OF NON-RESIDENT OWNERSHIP, 1981

| | Corporations | | Assets | | Equity | | Sales | | Profits | | Taxable Income | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (number) | (%) | ($ million) | (%) | ($ million) | (%) | ($ million) | (%) | ($ million) | (%) | ($ million) | (%) |
| **Metal mines** | | | | | | | | | | | | |
| Reporting corporations | | | | | | | | | | | | |
| Canadian | 68 | 51.5 | 17,555 | 71.8 | 9,390 | 72.8 | 6,208 | 63.5 | 1,398 | 78.0 | 240 | 60.0 |
| Foreign | 33 | 25.0 | 6,885 | 28.2 | 3,505 | 27.2 | 3,572 | 36.5 | 394 | 22.0 | 159 | 40.0 |
| Unclassified | 31 | 23.5 | 2 | -- | -- | -- | 1 | -- | -- | -- | -- | -- |
| Total all corporations | 132 | 100.0 | 24,443 | 100.0 | 12,895 | 100.0 | 9,782 | 100.0 | 1,792 | 100.0 | 400 | 100.0 |
| **Mineral fuels** | | | | | | | | | | | | |
| Reporting corporations | | | | | | | | | | | | |
| Canadian | 680 | 61.4 | 29,159 | 56.8 | 12,452 | 53.3 | 8,818 | 41.5 | 1,943 | 39.4 | 564 | 18.5 |
| Foreign | 157 | 14.2 | 22,151 | 43.1 | 10,904 | 46.7 | 12,390 | 58.4 | 2,980 | 60.5 | 2,485 | 81.4 |
| Unclassified | 271 | 24.4 | 25 | .1 | 10 | -- | 15 | .1 | 2 | .1 | 4 | .1 |
| Total all corporations | 1,108 | 100.0 | 51,335 | 100.0 | 23,367 | 100.0 | 21,222 | 100.0 | 4,926 | 100.0 | 3,053 | 100.0 |
| **Other mining** (including mining services) | | | | | | | | | | | | |
| Reporting corporations | | | | | | | | | | | | |
| Canadian | 2,209 | 47.2 | 7,421 | 64.4 | 3,036 | 58.4 | 3,583 | 59.0 | 403 | 45.9 | 409 | 68.0 |
| Foreign | 237 | 5.1 | 3,917 | 34.0 | 2,129 | 40.9 | 2,306 | 38.0 | 474 | 54.0 | 173 | 28.6 |
| Unclassified | 2,236 | 47.7 | 182 | 1.6 | 37 | .7 | 185 | 3.0 | 1 | .1 | 20 | 3.4 |
| Total all corporations | 4,682 | 100.0 | 11,520 | 100.0 | 5,202 | 100.0 | 6,074 | 100.0 | 878 | 100.0 | 602 | 100.0 |
| **Total mining** | | | | | | | | | | | | |
| Reporting corporations | | | | | | | | | | | | |
| Canadian | 2,957 | 49.9 | 54,135 | 62.0 | 24,878 | 60.0 | 18,609 | 50.2 | 3,744 | 49.3 | 1,213 | 29.9 |
| Foreign | 427 | 7.2 | 32,953 | 37.7 | 16,538 | 39.9 | 18,268 | 49.3 | 3,848 | 50.7 | 2,817 | 69.5 |
| Unclassified | 2,538 | 42.9 | 209 | .3 | 47 | .1 | 201 | .5 | 3 | -- | 24 | .6 |
| Total all corporations | 5,922 | 100.0 | 87,296 | 100.0 | 41,463 | 100.0 | 37,078 | 100.0 | 7,595 | 100.0 | 4,055 | 100.0 |

Note: Footnotes for Table 74 apply to this table. Figures may not add to totals due to rounding.

[1] Classification of the industry is the same as in Table 29.

-- Amount too small to be expressed.

### TABLE 74. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN THE MINERAL MANUFACTURING INDUSTRIES[1], BY DEGREE OF NON-RESIDENT OWNERSHIP, 1981

| | Corporations[2] | | Assets[4] | | Equity[5] | | Sales[6] | | Profits[7] | | Taxable income[8] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (number) | (%) | ($ million) | (%) | ($ million) | (%) | ($ million) | (%) | ($ million) | (%) | ($ million) | (%) |
| **Primary metal products** | | | | | | | | | | | | |
| Reporting corporations[2] | | | | | | | | | | | | |
| Canadian | 240 | 67.6 | 12,689 | 86.9 | 5,480 | 85.4 | 11,184 | 85.2 | 1,160 | 89.7 | 298 | 80.1 |
| Foreign | 41 | 11.5 | 1,904 | 13.0 | 938 | 14.6 | 1,925 | 14.8 | 132 | 10.3 | 73 | 19.7 |
| Unclassified[3] | 74 | 20.9 | 7 | .1 | 2 | - | 12 | - | 1 | - | 1 | .2 |
| Total all corporations | 355 | 100.0 | 14,600 | 100.0 | 6,420 | 100.0 | 13,121 | 100.0 | 1,293 | 100.0 | 372 | 100.0 |
| **Nonmetallic mineral products** | | | | | | | | | | | | |
| Reporting corporations[2] | | | | | | | | | | | | |
| Canadian | 798 | 52.0 | 1,964 | 30.6 | 615 | 23.5 | 2,195 | 40.1 | 101 | 24.8 | 69 | 40.1 |
| Foreign | 82 | 5.3 | 4,390 | 68.5 | 1,987 | 76.1 | 3,186 | 58.2 | 305 | 74.9 | 99 | 57.6 |
| Unclassified[3] | 655 | 42.7 | 58 | .9 | 10 | .4 | 92 | 1.7 | 1 | .3 | 4 | 2.3 |
| Total all corporations | 1,535 | 100.0 | 6,412 | 100.0 | 2,612 | 100.0 | 5,473 | 100.0 | 407 | 100.0 | 172 | 100.0 |
| **Petroleum and coal products** | | | | | | | | | | | | |
| Reporting corporations[2] | | | | | | | | | | | | |
| Canadian | 39 | 63.9 | 11,079 | 39.5 | 4,131 | 30.6 | 6,409 | 22.0 | 801 | 27.0 | 325 | 17.8 |
| Foreign | 14 | 23.0 | 16,986 | 60.5 | 9,381 | 69.4 | 22,680 | 78.0 | 2,164 | 73.0 | 1,498 | 82.2 |
| Unclassified[3] | 8 | 13.1 | 1 | - | -- | - | 1 | - | -- | - | -- | - |
| Total all corporations | 61 | 100.0 | 28,066 | 100.0 | 13,512 | 100.0 | 29,090 | 100.0 | 2,965 | 100.0 | 1,823 | 100.0 |
| **Total mineral manufacturing industries** | | | | | | | | | | | | |
| Reporting corporations[2] | | | | | | | | | | | | |
| Canadian | 1,077 | 55.2 | 25,732 | 52.4 | 10,226 | 45.4 | 19,788 | 41.5 | 2,062 | 44.2 | 692 | 29.2 |
| Foreign | 137 | 7.0 | 23,280 | 47.4 | 12,306 | 54.6 | 27,791 | 58.3 | 2,601 | 55.8 | 1,670 | 70.6 |
| Unclassified[3] | 737 | 37.8 | 66 | .2 | 12 | - | 105 | .2 | 2 | - | 5 | .2 |
| Total all corporations | 1,951 | 100.0 | 49,078 | 100.0 | 22,544 | 100.0 | 47,684 | 100.0 | 4,665 | 100.0 | 2,367 | 100.0 |

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[1] Classification of industries is the same as in Table 30. [2] Corporations reporting under the Corporations and Labour Unions Returns Act. A corporation is considered to be foreign controlled if 50 per cent or more of its voting rights are known to be held outside Canada, and/or by one or more Canadian corporations which are, in turn, foreign controlled. Each corporation is classified according to the percentage of its voting rights which are owned by non-residents, either directly or through other Canadian corporations, and the whole of the corporation is assigned to this particular degree of foreign ownership. [3] Corporations exempt from reporting under the Corporations and Labour Unions Returns Act. These include corporations reporting under other acts, small companies and corporations and non-profit organizations. [4] Included are cash, marketable securities, accounts receivable, inventories, fixed assets, investments in affiliated corporations and other assets. The amounts tabulated are those shown on the balance sheets of corporations after deducting allowances for doubtful accounts, amortization, depletion and depreciation. [5] Equity represents the shareholders' interest in the net assets of the corporation and includes the total amount of all issued and paid-up share capital, earnings retained in the business and other surplus accounts such as contributed and capital surplus. [6] For non-financial corporations, sales are gross revenues from non-financial operations. For financial corporations sales include income from financial as well as non-financial sources. [7] The net earnings from operations, investment income and net capital gains. Profits are tabulated after deducting allowances for amortization, depletion and depreciation, but before income tax provisions or declaration of dividends. [8] Taxable income figures are as reported by corporations prior to assessment by the Department of National Revenue. They include earnings in the reference year after the deduction of applicable losses of other years.
-- Amount too small to be expressed; - Nil.

## TABLE 75. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN NON-FINANCIAL INDUSTRIES, BY MAJOR INDUSTRY GROUP AND BY CONTROL, 1980 AND 1981

| | Agriculture, Forestry, Fishing and Trapping | | Mines Quarries & Oil Wells | | Manufacturing | | Construction | | Transportation, Communication and Other Utilities | | Trade | | Services | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1980 | 1981P | 1980 | 1981P | 1980 | 1981P | 1980 | 1981P | 1980 | 1981P | 1980 | 1981P | 1980 | 1981P | 1980 | 1981P |
| | | | | | | | | (number) | | | | | | | | |
| **Number of corporations** | | | | | | | | | | | | | | | | |
| Canadian control | 8,285 | 9,572 | 2,489 | 2,957 | 16,243 | 17,172 | 15,705 | 16,964 | 5,119 | 5,616 | 44,345 | 47,938 | 5,844 | 6,341 | 98,030 | 106,560 |
| Foreign control | 101 | 95 | 481 | 427 | 2,096 | 1,922 | 216 | 191 | 180 | 161 | 1,951 | 1,721 | 303 | 269 | 5,328 | 4,786 |
| Other corporations | 10,526 | 10,446 | 2,411 | 2,538 | 18,138 | 17,882 | 39,830 | 40,561 | 13,054 | 13,823 | 73,859 | 72,468 | 13,342 | 14,092 | 171,160 | 171,810 |
| Total corporations | 18,912 | 20,103 | 5,381 | 5,922 | 36,477 | 36,976 | 55,751 | 57,716 | 18,353 | 19,600 | 120,155 | 122,127 | 19,489 | 20,702 | 274,518 | 283,146 |
| | | | | | | | | ($ million) | | | | | | | | |
| **Assets** | | | | | | | | | | | | | | | | |
| Canadian control | 6,390 | 8,475 | 38,260 | 54,135 | 73,561 | 90,073 | 16,409 | 18,715 | 5,032 | 5,289 | 55,434 | 65,400 | 107,766 | 120,429 | 302,852 | 362,516 |
| Foreign control | 334 | 401 | 30,705 | 32,953 | 69,093 | 73,997 | 2,217 | 2,504 | 106,022 | 117,893 | 14,576 | 16,120 | 5,129 | 5,377 | 228,076 | 249,245 |
| Other corporations | 973 | 989 | 193 | 209 | 1,407 | 1,402 | 2,450 | 2,522 | 924 | 982 | 5,324 | 5,286 | 947 | 1,004 | 12,218 | 12,394 |
| Total corporations | 7,697 | 9,865 | 69,158 | 87,297 | 144,061 | 165,472 | 21,076 | 23,741 | 111,978 | 124,164 | 75,334 | 86,806 | 113,842 | 126,810 | 543,146 | 624,155 |
| **Equity** | | | | | | | | | | | | | | | | |
| Canadian control | 1,965 | 2,671 | 17,765 | 24,878 | 28,450 | 31,629 | 3,743 | 4,109 | 1,738 | 1,801 | 16,349 | 19,481 | 29,938 | 32,166 | 99,948 | 116,735 |
| Foreign control | 111 | 139 | 16,297 | 16,538 | 35,017 | 35,891 | 710 | 812 | 29,434 | 31,559 | 5,013 | 5,531 | 1,754 | 1,818 | 88,336 | 92,288 |
| Other corporations | 206 | 195 | 51 | 47 | 263 | 249 | 533 | 501 | 168 | 161 | 1,167 | 1,029 | 171 | 164 | 2,559 | 2,346 |
| Total corporations | 2,282 | 3,005 | 34,113 | 41,463 | 63,730 | 67,768 | 4,986 | 5,422 | 31,340 | 33,521 | 22,529 | 26,042 | 31,863 | 34,148 | 190,843 | 211,369 |
| **Sales** | | | | | | | | | | | | | | | | |
| Canadian control | 5,663 | 6,759 | 14,519 | 18,609 | 94,194 | 109,336 | 23,693 | 27,476 | 3,212 | 3,656 | 140,023 | 160,088 | 45,453 | 52,026 | 326,757 | 377,950 |
| Foreign control | 290 | 310 | 20,451 | 18,268 | 101,405 | 108,125 | 2,769 | 3,728 | 43,442 | 49,749 | 39,479 | 41,982 | 3,265 | 3,717 | 211,101 | 225,879 |
| Other corporations | 1,053 | 1,088 | 183 | 201 | 2,602 | 2,641 | 5,082 | 5,310 | 1,453 | 1,572 | 11,040 | 11,169 | 1,485 | 1,601 | 22,898 | 23,582 |
| Total corporations | 7,006 | 8,157 | 35,153 | 37,078 | 198,201 | 220,102 | 31,544 | 36,514 | 48,107 | 54,977 | 190,542 | 213,239 | 50,203 | 57,344 | 560,756 | 627,411 |
| **Profits** | | | | | | | | | | | | | | | | |
| Canadian control | 512 | 357 | 4,786 | 3,744 | 6,872 | 6,891 | 987 | 1,095 | 450 | 435 | 5,159 | 5,240 | 4,557 | 5,123 | 23,323 | 22,885 |
| Foreign control | 24 | 22 | 5,568 | 3,848 | 8,137 | 7,468 | 154 | 160 | 4,411 | 4,918 | 1,242 | 1,213 | 455 | 440 | 19,991 | 18,069 |
| Other corporations | 84 | 72 | 17 | 3 | 100 | 92 | 194 | 189 | 62 | 52 | 360 | 293 | 64 | 54 | 881 | 755 |
| Total corporations | 620 | 451 | 10,371 | 7,595 | 15,109 | 14,451 | 1,335 | 1,444 | 4,923 | 5,405 | 6,761 | 6,746 | 5,076 | 5,617 | 44,195 | 41,709 |

Note: Figures may not add to totals due to rounding.
P Preliminary.

## TABLE 76. CANADA, CAPITAL AND REPAIR EXPENDITURES BY SELECTED INDUSTRIAL SECTOR; 1982-84

| | | Capital Expenditures | | | Repair Expenditures | | | Capital and Repair Expenditures | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Construction | Machinery and Equipment | Total | Construction | Machinery and Equipment | Total | Construction | Machinery and Equipment | Total |
| | | | | | | ($ million) | | | | |
| Agriculture | 1982 | 1,314.5 | 3,027.1 | 4,341.6 | 347.6 | 1,065.0 | 1,412.6 | 1,662.1 | 4,092.1 | 5,754.2 |
| | 1983P | 1,389.3 | 3,152.4 | 4,541.7 | 369.1 | 1,070.3 | 1,439.4 | 1,758.4 | 4,222.7 | 5,981.1 |
| | 1984$^f$ | 1,421.3 | 3,383.7 | 4,805.0 | 386.5 | 1,098.1 | 1,484.6 | 1,807.8 | 4,481.8 | 6,289.6 |
| Forestry | 1982 | 93.5 | 54.5 | 148.0 | 65.9 | 189.0 | 254.9 | 159.4 | 243.5 | 402.9 |
| | 1983P | 91.6 | 51.7 | 144.3 | 74.7 | 230.9 | 305.6 | 166.3 | 283.6 | 449.9 |
| | 1984$^f$ | 119.7 | 105.5 | 225.2 | 82.2 | 238.3 | 320.5 | 201.9 | 343.8 | 545.7 |
| Mining[1] | 1982 | 8,007.2 | 2,354.4 | 10,361.6 | 625.4 | 1,935.2 | 2,560.6 | 8,632.6 | 4,289.6 | 12,922.2 |
| | 1983P | 7,777.3 | 1,830.0 | 9,607.3 | 606.5 | 1,899.9 | 2,506.4 | 8,383.8 | 3,729.9 | 12,113.7 |
| | 1984$^f$ | 8,391.6 | 1,629.9 | 10,021.5 | 669.3 | 2,129.1 | 2,798.4 | 9,060.9 | 3,759.0 | 12,819.9 |
| Construction | 1982 | 206.9 | 1,086.5 | 1,293.4 | 28.5 | 830.0 | 858.5 | 235.4 | 1,916.5 | 2,151.9 |
| | 1983P | 207.1 | 1,088.9 | 1,296.0 | 28.6 | 831.7 | 860.3 | 235.7 | 1,920.6 | 2,156.3 |
| | 1984$^f$ | 207.3 | 1,089.6 | 1,296.9 | 28.7 | 832.3 | 861.0 | 236.0 | 1,921.9 | 2,157.9 |
| Housing | 1982 | 10,148.8 | - | 10,148.8 | 3,432.8 | - | 3,432.8 | 13,581.6 | - | 13,581.6 |
| | 1983P | 12,871.8 | - | 12,871.8 | 3,811.2 | - | 3,811.2 | 16,683.0 | - | 16,683.0 |
| | 1984$^f$ | 13,163.7 | - | 13,163.7 | 4,076.2 | - | 4,076.3 | 17,239.9 | - | 17,239.9 |
| Manufacturing | 1982 | 2,908.7 | 8,583.8 | 11,492.5 | 797.6 | 4,056.7 | 4,854.3 | 3,706.3 | 12,640.5 | 16,346.8 |
| | 1983P | 1,869.1 | 6,932.6 | 8,861.7 | 768.1 | 4,129.4 | 4,897.5 | 2,637.2 | 11,062.0 | 13,699.2 |
| | 1984$^f$ | 1,912.8 | 6,671.6 | 8,584.4 | 820.2 | 4,264.5 | 5,084.7 | 2,733.0 | 10,936.1 | 13,669.1 |
| Utilities | 1982 | 9,609.7 | 8,243.4 | 17,853.1 | 1,462.5 | 3,979.5 | 5,442.0 | 11,072.2 | 12,222.9 | 23,295.1 |
| | 1983P | 8,078.3 | 7,955.4 | 16,033.7 | 1,560.3 | 4,185.2 | 5,745.5 | 9,638.6 | 12,140.6 | 21,779.2 |
| | 1984$^f$ | 7,566.1 | 7,692.6 | 15,258.7 | 1,731.6 | 4,538.7 | 6,271.3 | 9,297.7 | 12,232.2 | 21,530.0 |
| Trade | 1982 | 629.1 | 1,307.4 | 1,936.5 | 241.2 | 315.9 | 557.1 | 870.3 | 1,623.3 | 2,493.6 |
| | 1983P | 607.8 | 1,340.7 | 1,948.5 | 226.1 | 308.2 | 534.3 | 833.9 | 1,648.9 | 2,482.8 |
| | 1984$^f$ | 488.6 | 1,479.4 | 1,968.0 | 239.0 | 315.8 | 554.8 | 727.6 | 1,795.2 | 2,522.8 |
| Other[2] | 1982 | 13,572.1 | 5,586.4 | 19,158.2 | 2,545.8 | 1,143.1 | 3,688.9 | 16,144.9 | 6,729.5 | 22,874.4 |
| | 1983P | 13,211.8 | 5,968.4 | 19,180.2 | 2,547.1 | 1,091.2 | 3,638.3 | 15,758.9 | 7,059.6 | 22,818.5 |
| | 1984$^f$ | 13,046.9 | 6,690.6 | 19,737.5 | 2,619.4 | 1,182.2 | 3,801.6 | 15,666.3 | 7,872.8 | 23,539.1 |
| Total | 1982 | 46,517.5 | 30,243.5 | 76,761.0 | 9,547.3 | 13,514.4 | 23,061.7 | 56,064.8 | 43,757.9 | 99,822.7 |
| | 1983P | 46,104.1 | 28,321.1 | 74,425.2 | 9,991.7 | 13,746.5 | 23,738.5 | 56,095.8 | 42,067.9 | 98,163.7 |
| | 1984$^f$ | 46,318.0 | 28,742.9 | 75,060.9 | 10,653.1 | 14,600.0 | 25,253.1 | 56,971.1 | 43,342.9 | 100,314.0 |
| Mining as a percentage of total | 1982 | 17.2 | 7.8 | 13.5 | 6.6 | 14.3 | 11.1 | 15.4 | 9.8 | 12.9 |
| | 1983P | 16.9 | 6.5 | 12.9 | 6.1 | 13.8 | 10.6 | 14.9 | 8.9 | 12.3 |
| | 1984$^f$ | 18.1 | 5.7 | 13.4 | 6.3 | 14.6 | 11.9 | 15.9 | 8.7 | 12.8 |

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[1] Includes mines, quarries and oil wells. [2] Includes finance, real estate, insurance, commercial services, institutions and government departments.
P Preliminary; $^f$ Forecast; - Nil.

### TABLE 77. CANADA, CAPITAL AND REPAIR EXPENDITURES IN MINING[1] BY GEOGRAPHICAL REGION; 1982-84

| | | Capital Expenditures | | | Repair Expenditures | | | Capital and Repair Expenditures | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Construction | Machinery and Equipment | Total | Construction | Machinery and Equipment | Total | Construction | Machinery and Equipment | Total |
| | | | | | | ($ million) | | | | |
| Atlantic Region | 1982 | 878.6 | 516.0 | 1,394.1 | 16.3 | 176.5 | 192.8 | 894.9 | 692.5 | 1,587.4 |
| | 1983P | 1,289.4 | 379.6 | 1,669.0 | 13.3 | 165.8 | 179.1 | 1,302.7 | 545.4 | 1,848.1 |
| | 1984$^{f}$ | 1,524.3 | 173.2 | 1,697.5 | 15.1 | 182.0 | 197.1 | 1,539.4 | 355.2 | 1,894.6 |
| Quebec | 1982 | 245.3 | 81.7 | 327.0 | 43.5 | 197.1 | 240.6 | 288.8 | 278.8 | 567.6 |
| | 1983P | 167.8 | 53.1 | 220.9 | 41.3 | 209.3 | 250.6 | 209.1 | 262.4 | 471.5 |
| | 1984$^{f}$ | 210.0 | 75.5 | 285.5 | 40.9 | 222.5 | 263.4 | 250.9 | 298.0 | 548.9 |
| Ontario | 1982 | 447.6 | 116.9 | 564.5 | 35.6 | 270.6 | 306.2 | 483.2 | 387.5 | 870.7 |
| | 1983P | 389.9 | 128.1 | 518.0 | 38.0 | 286.6 | 324.6 | 427.9 | 414.7 | 842.6 |
| | 1984$^{f}$ | 425.0 | 194.2 | 619.2 | 47.1 | 328.0 | 375.1 | 472.1 | 522.2 | 994.3 |
| Prairie Region | 1982 | 4,415.6 | 855.7 | 5,271.3 | 458.3 | 891.4 | 1,349.7 | 4,873.9 | 1,747.1 | 6,621.0 |
| | 1983P | 3,988.2 | 802.0 | 4,790.2 | 458.2 | 840.7 | 1,298.9 | 4,446.4 | 1,642.7 | 6,089.1 |
| | 1984$^{f}$ | 4,668.5 | 875.1 | 5,543.6 | 505.9 | 927.1 | 1,433.0 | 5,174.4 | 1,802.2 | 6,976.6 |
| British Columbia | 1982 | 889.5 | 211.2 | 1,100.7 | 61.4 | 340.8 | 402.2 | 950.9 | 552.0 | 1,502.9 |
| | 1983P | 872.5 | 196.3 | 1,068.8 | 47.3 | 347.3 | 394.6 | 919.8 | 543.6 | 1,463.4 |
| | 1984$^{f}$ | 348.2 | 214.9 | 563.1 | 48.3 | 411.9 | 460.2 | 396.5 | 626.8 | 1,023.3 |
| Yukon and Northwest Territories | 1982 | 1,130.6 | 572.9 | 1,703.5 | 10.3 | 58.8 | 69.1 | 1,140.9 | 631.7 | 1,772.6 |
| | 1983P | 1,069.5 | 270.9 | 1,340.4 | 8.4 | 50.2 | 58.6 | 1,077.9 | 321.1 | 1,399.0 |
| | 1984$^{f}$ | 1,215.6 | 97.0 | 1,312.6 | 12.0 | 57.6 | 69.6 | 1,227.6 | 154.6 | 1,382.2 |
| Canada, total | 1982 | 8,007.2 | 2,354.4 | 10,361.6 | 625.4 | 1,935.2 | 2,560.6 | 8,632.6 | 4,289.6 | 12,922.2 |
| | 1983P | 7,777.3 | 1,830.0 | 9,607.3 | 606.5 | 1,899.9 | 2,506.4 | 8,383.8 | 3,729.9 | 12,113.7 |
| | 1984$^{f}$ | 8,391.6 | 1,629.9 | 10,021.5 | 669.3 | 2,129.1 | 2,798.4 | 9,060.9 | 3,759.0 | 12,819.9 |

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[1] Includes mines, quarries and oil wells.
P Preliminary; $^{f}$ Forecast.

## TABLE 78. CANADA, CAPITAL AND REPAIR EXPENDITURES IN MINING[1] AND MINERAL MANUFACTURING INDUSTRIES, 1982-84

| | 1982 | | | 1983P | | | 1984f | | |
|---|---|---|---|---|---|---|---|---|---|
| | Capital | Repair | Total | Capital | Repair | Total | Capital | Repair | Total |
| | | | | | ($ million) | | | | |
| **Mining industry** | | | | | | | | | |
| Metal mines | | | | | | | | | |
| Gold | 397.4 | 58.7 | 456.1 | 326.0 | 69.7 | 395.7 | 503.8 | 79.0 | 582.8 |
| Silver-lead-zinc | 145.1 | 119.6 | 264.7 | 64.7 | 105.3 | 170.0 | 94.8 | 101.9 | 196.7 |
| Copper-gold-silver | 212.0 | 264.2 | 476.2 | 152.5 | 257.5 | 410.0 | 288.6 | 297.7 | 586.3 |
| Iron | 141.5 | 270.4 | 411.9 | 81.1 | 244.0 | 325.1 | 91.2 | 244.2 | 335.4 |
| Other metal mines | 574.0 | 204.6 | 778.6 | 462.8 | 214.6 | 677.4 | 421.0 | 280.2 | 701.2 |
| Total metal mines | 1,470.0 | 917.5 | 2,387.5 | 1,087.1 | 891.1 | 1,978.2 | 1,399.4 | 1,003.0 | 2,402.4 |
| Nonmetal mines | | | | | | | | | |
| Asbestos | 52.2 | 59.4 | 111.6 | 36.9 | 76.5 | 113.4 | 35.7 | 81.3 | 117.0 |
| Other nonmetal mines[2] | 1,399.7 | 401.0 | 1,800.7 | 1,391.8 | 414.0 | 1,805.8 | 788.9 | 488.6 | 1,277.5 |
| Total nonmetal mines | 1,451.9 | 460.4 | 1,912.3 | 1,428.7 | 490.5 | 1,919.2 | 824.6 | 569.9 | 1,394.5 |
| Mineral fuels | | | | | | | | | |
| Oil, crude and gas[3] | 7,439.7 | 1,182.7 | 8,622.4 | 7,091.5 | 1,124.8 | 8,216.3 | 7,797.5 | 1,225.5 | 9,023.0 |
| Total mining industries | 10,361.6 | 2,560.6 | 12,922.2 | 9,607.3 | 2,506.4 | 12,113.7 | 10,021.5 | 2,798.4 | 12,819.9 |
| **Mineral manufacturing** | | | | | | | | | |
| Primary metal industries | | | | | | | | | |
| Iron and steel mills | 416.3 | 685.8 | 1,102.1 | 198.3 | 555.1 | 753.4 | 226.5 | 577.6 | 804.1 |
| Steel pipe and tube mills | 191.5 | 66.8 | 258.3 | 70.2 | 40.4 | 110.6 | 56.4 | 40.5 | 96.9 |
| Iron foundries | 13.3 | 39.0 | 52.3 | 9.7 | 38.3 | 48.0 | 24.1 | 39.1 | 63.2 |
| Smelting and refining | 525.5 | 281.8 | 807.3 | 377.7 | 377.1 | 754.8 | 772.1 | 386.1 | 1,158.2 |
| Aluminum rolling, casting and extruding | 20.1 | 31.5 | 51.6 | 22.2 | 44.5 | 66.7 | 42.3 | 46.5 | 88.8 |
| Copper and copper alloy rolling, casting and extruding | 22.9 | 4.8 | 27.7 | 6.1 | 6.3 | 12.4 | 13.5 | 7.3 | 20.8 |
| Metal rolling, casting and extruding | 16.2 | 11.1 | 27.3 | 9.0 | 7.1 | 16.1 | 8.5 | 7.4 | 15.9 |
| Total primary metal industries | 1,205.8 | 1,120.8 | 2,326.6 | 693.2 | 1,068.8 | 1,762.0 | 1,143.4 | 1,104.5 | 2,247.9 |
| Nonmetallic mineral products | | | | | | | | | |
| Cement | 47.1 | 64.5 | 111.6 | 36.3 | 65.6 | 101.9 | 29.5 | 66.9 | 96.4 |
| Stone products | 3.7 | 1.2 | 4.9 | 0.6 | 0.6 | 1.2 | 1.6 | 0.7 | 2.3 |
| Concrete products | 9.8 | 26.2 | 36.0 | 11.4 | 23.1 | 34.5 | 12.3 | 25.7 | 38.0 |
| Ready-mix concrete | 20.0 | 54.2 | 74.2 | 12.3 | 45.1 | 57.4 | 11.8 | 43.5 | 55.3 |
| Clay products | 9.3 | 6.7 | 16.0 | 5.9 | 6.5 | 12.4 | 5.3 | 7.0 | 12.3 |
| Glass and glass products | 29.1 | 19.9 | 49.0 | 37.8 | 23.4 | 61.2 | 53.4 | 32.3 | 85.7 |
| Abrasives | 12.2 | 13.1 | 25.3 | 6.3 | 11.2 | 17.5 | 7.9 | 11.4 | 19.3 |
| Lime | 7.9 | 3.3 | 11.2 | 2.2 | 2.8 | 5.0 | 3.6 | 2.5 | 6.1 |
| Other nonmetallic mineral products | 27.3 | 42.7 | 70.0 | 20.1 | 42.0 | 62.1 | 34.6 | 41.9 | 76.5 |
| Total nonmetallic mineral products | 166.4 | 231.8 | 398.2 | 132.9 | 220.3 | 353.2 | 160.0 | 231.9 | 391.9 |
| Petroleum and coal products | 1,224.5 | 319.7 | 1,544.2 | 734.1 | 272.6 | 1,006.7 | 519.9 | 271.7 | 791.6 |
| Total mineral manufacturing industries | 2,596.7 | 1,672.3 | 4,269.0 | 1,560.2 | 1,561.7 | 3,121.9 | 1,823.3 | 1,608.1 | 3,431.4 |
| Total mining and mineral manufacturing industries | 12,958.3 | 4,232.9 | 17,191.2 | 11,167.5 | 4,068.1 | 15,235.6 | 11,844.8 | 4,406.5 | 16,251.3 |

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[1] Does not include cement, lime and clay products (domestic clay) manufacturing, smelting and refining. [2] Includes coal mines, gypsum, salt, potash and miscellaneous nonmetal mines and quarrying. [3] The total of capital expenditures shown under "petroleum and gas" is equal to the total capital expenditure under the column entitled "petroleum and natural gas extraction" and under the column "natural gas processing plants" of Table 80.

P Preliminary; f Forecast.

## TABLE 79. CANADA, CAPITAL AND REPAIR EXPENDITURES IN THE MINING INDUSTRY[1], 1978-84

| | 1978 | 1979 | 1980 | 1981 | 1982 | 1983P | 1984f |
|---|---|---|---|---|---|---|---|
| | | | | ($ million) | | | |
| **Metal mines** | | | | | | | |
| Capital | | | | | | | |
| Construction | 407.3 | 606.4 | 1,109.1 | 1,331.3 | 1,099.4 | 806.4 | 912.4 |
| Machinery | 169.3 | 281.6 | 467.2 | 576.4 | 370.6 | 280.4 | 487.0 |
| Total | 576.6 | 888.0 | 1,576.3 | 1,907.7 | 1,470.0 | 1,087.1 | 1,399.4 |
| Repair | | | | | | | |
| Construction | 53.7 | 70.2 | 137.3 | 151.9 | 112.4 | 104.6 | 119.4 |
| Machinery | 487.6 | 632.1 | 767.7 | 900.8 | 805.1 | 786.5 | 88[illegible].6 |
| Total | 541.3 | 702.3 | 905.0 | 1,052.7 | 917.5 | 891.1 | 1,003.0 |
| Total capital and repair | 1,117.9 | 1,590.3 | 2,481.3 | 2,960.4 | 2,387.5 | 1,978.2 | 2,402.4 |
| **Nonmetal mines[2]** | | | | | | | |
| Capital | | | | | | | |
| Construction | 187.5 | 248.8 | 346.4 | 647.8 | 888.6 | 948.8 | 373.8 |
| Machinery | 236.4 | 202.6 | 267.6 | 417.7 | 563.3 | 479.9 | 450.8 |
| Total | 423.9 | 451.4 | 614.0 | 1,065.5 | 1,451.9 | 1,428.7 | 824.6 |
| Repair | | | | | | | |
| Construction | 18.2 | 14.6 | 32.5 | 26.0 | 28.6 | 21.0 | 22.6 |
| Material | 289.1 | 332.5 | 393.1 | 447.8 | 431.8 | 469.5 | 547.3 |
| Total | 307.3 | 347.1 | 425.6 | 473.8 | 460.4 | 490.5 | 569.9 |
| Total capital and repair | 731.2 | 798.5 | 1,039.6 | 1,539.3 | 1,912.3 | 1,919.2 | 1,394.5 |
| **Mineral fuels** | | | | | | | |
| Capital | | | | | | | |
| Construction | 2,520.9 | 3,820.3 | 5,453.1 | 5,825.1 | 6,019.2 | 6,021.8 | 7,105.4 |
| Machinery | 382.0 | 494.9 | 800.3 | 1,206.3 | 1,420.5 | 1,069.7 | 692.1 |
| Total | 2,902.9 | 4,315.2 | 6,253.4 | 7,031.4 | 7,439.7 | 7,091.5 | 7,797.5 |
| Repair | | | | | | | |
| Construction | 389.6 | 444.1 | 627.6 | 514.4 | 484.4 | 480.9 | 527.3 |
| Machinery | 100.2 | 242.1 | 313.6 | 639.0 | 698.3 | 643.9 | 698.2 |
| Total | 489.8 | 686.2 | 941.2 | 1,153.4 | 1,182.7 | 1,124.8 | 1,225.5 |
| Total capital and repair | 3,392.7 | 5,001.4 | 7,194.6 | 8,184.8 | 8,622.4 | 8,216.3 | 9,023.0 |
| **Total mining** | | | | | | | |
| Capital | | | | | | | |
| Construction | 3,115.7 | 4,675.5 | 6,908.6 | 7,804.2 | 8,007.2 | 7,777.3 | 8,391.6 |
| Machinery | 787.7 | 979.1 | 1,535.1 | 2,200.4 | 2,354.4 | 1,830.0 | 1,629.9 |
| Total | 3,903.4 | 5,654.6 | 8,443.7 | 10,004.6 | 10,361.6 | 9,607.3 | 10,021.5 |
| Repair | | | | | | | |
| Construction | 461.5 | 528.9 | 797.4 | 692.5 | 625.4 | 606.5 | 669.3 |
| Machinery | 876.9 | 1,206.7 | 1,474.4 | 1,987.6 | 1,935.2 | 1,899.9 | 2,129.1 |
| Total | 1,338.4 | 1,735.6 | 2,271.8 | 2,680.1 | 2,560.6 | 2,506.4 | 2,798.4 |
| Total capital and repair | 5,241.8 | 7,390.2 | 10,715.5 | 12,684.7 | 12,922.2 | 12,113.7 | 12,819.9 |

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[1] Does not include cement, lime and clay products (domestic clays) manufacturing, smelting and refining. [2] Includes coal mines, asbestos, gypsum, salt, potash, miscellaneous nonmetals, quarrying and sand pits.
P Preliminary; f Forecast.

**TABLE 80. CANADA, CAPITAL AND REPAIR EXPENDITURES IN THE MINERAL MANUFACTURING INDUSTRIES[1], 1978-84**

| | 1978 | 1979 | 1980 | 1981 | 1982 | 1983P | 1984[f] |
|---|---|---|---|---|---|---|---|
| | | | | ($ million) | | | |
| **Primary metal industries[2]** | | | | | | | |
| Capital | | | | | | | |
| Construction | 130.7 | 153.4 | 328.2 | 330.1 | 278.3 | 207.4 | 606.7 |
| Machinery | 475.4 | 621.1 | 960.9 | 1,289.6 | 927.5 | 485.8 | 536.7 |
| Total | 606.1 | 774.5 | 1,289.1 | 1,619.7 | 1,205.8 | 693.2 | 1,143.4 |
| Repair | | | | | | | |
| Construction | 80.8 | 87.6 | 122.1 | 139.0 | 99.2 | 110.2 | 118.6 |
| Machinery | 780.1 | 887.7 | 998.5 | 1,053.3 | 1,021.6 | 958.6 | 985.9 |
| Total | 860.9 | 975.3 | 1,120.6 | 1,192.3 | 1,120.8 | 1,068.8 | 1,104.5 |
| Total capital and repair | 1,467.0 | 1,749.8 | 2,409.7 | 2,812.0 | 2,326.6 | 1,762.0 | 2,247.9 |
| **Nonmetallic mineral products[3]** | | | | | | | |
| Capital | | | | | | | |
| Construction | 62.0 | 102.0 | 70.0 | 93.4 | 32.0 | 15.2 | 13.6 |
| Machinery | 217.9 | 293.5 | 249.7 | 254.0 | 134.4 | 117.7 | 146.4 |
| Total | 279.9 | 395.5 | 319.7 | 347.4 | 166.4 | 132.9 | 160.0 |
| Repair | | | | | | | |
| Construction | 17.5 | 20.2 | 16.7 | 23.7 | 20.7 | 20.5 | 20.2 |
| Machinery | 190.3 | 206.1 | 213.8 | 227.5 | 211.1 | 199.8 | 211.7 |
| Total | 207.8 | 226.3 | 230.5 | 251.2 | 231.8 | 220.3 | 231.9 |
| Total capital and repair | 487.7 | 621.8 | 550.2 | 598.6 | 398.2 | 353.2 | 391.9 |
| **Petroleum and coal products** | | | | | | | |
| Capital | | | | | | | |
| Construction | 215.6 | 180.0 | 215.6 | 629.9 | 890.8 | 542.9 | 378.3 |
| Machinery | 99.5 | 94.0 | 109.1 | 215.0 | 333.7 | 191.2 | 141.6 |
| Total | 315.1 | 274.0 | 324.7 | 844.9 | 1,224.5 | 734.1 | 519.9 |
| Repair | | | | | | | |
| Construction | 117.5 | 158.1 | 190.5 | 212.9 | 218.5 | 198.1 | 197.2 |
| Machinery | 57.4 | 61.3 | 76.2 | 89.1 | 101.2 | 74.5 | 74.5 |
| Total | 174.9 | 219.4 | 266.7 | 302.0 | 319.7 | 272.6 | 271.7 |
| Total capital and repair | 490.0 | 493.4 | 591.4 | 1,146.9 | 1,544.2 | 1,006.7 | 791.6 |
| **Total mineral manufacturing industries** | | | | | | | |
| Capital | | | | | | | |
| Construction | 408.3 | 435.4 | 613.8 | 1,053.4 | 1,201.1 | 765.5 | 998.6 |
| Machinery | 792.8 | 1,008.6 | 1,319.7 | 1,758.6 | 1,395.6 | 794.7 | 824.7 |
| Total | 1,201.1 | 1,444.0 | 1,933.5 | 2,812.0 | 2,596.7 | 1,560.2 | 1,823.3 |
| Repair | | | | | | | |
| Construction | 215.8 | 256.9 | 329.3 | 375.6 | 338.4 | 328.8 | 336.0 |
| Machinery | 1,027.8 | 1,155.1 | 1,288.5 | 1,369.9 | 1,333.9 | 1,232.9 | 1,272.1 |
| Total | 1,243.6 | 1,412.0 | 1,617.8 | 1,745.5 | 1,672.3 | 1,561.7 | 1,608.1 |
| Total capital and repair | 2,444.7 | 2,856.0 | 3,551.3 | 4,557.5 | 4,269.0 | 3,121.9 | 3,431.4 |

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[1] Industry groups are the same as in Table 28. [2] Includes smelting and refining. [3] Includes cement, lime and clay products manufacturing.
P Preliminary; [f] Forecast.

TABLE 81. CANADA, CAPITAL EXPENDITURES IN THE PETROLEUM, NATURAL GAS AND ALLIED INDUSTRIES[1], 1978-84

| | Petroleum and Natural Gas Extraction[2] | Transportation Including Rail, Water and Pipelines | Marketing (Chiefly Outlets of Oil Companies) | Natural Gas Distribution | Petroleum and Coal Products Industries | Natural Gas Processing Plants | Total Capital Expenditures |
|---|---|---|---|---|---|---|---|
| | | | | ($ million) | | | |
| 1978 | 2,684.1 | 312.4 | 145.6 | 246.6 | 315.1 | 218.8 | 3,922.6 |
| 1979 | 4,013.4 | 229.3 | 134.3 | 262.5 | 274.0 | 301.8 | 5,215.3 |
| 1980 | 5,744.2 | 602.1 | 205.2 | 386.4 | 324.7 | 311.5 | 7,574.1 |
| 1981 | 6,444.9 | 1,745.7 | 264.1 | 408.7 | 844.9 | 311.6 | 10,046.9 |
| 1982 | 6,743.4 | 1,994.3 | 320.5 | 517.6 | 1,224.5 | 522.8 | 11,323.1 |
| 1983P | 6,624.7 | 630.2 | 384.4 | 525.5 | 734.1 | 277.8 | 9,176.7 |
| 1984f | 7,464.0 | 728.1 | 380.2 | 555.4 | 519.9 | 307.0 | 9,954.6 |

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[1] The petroleum and natural gas industries in this table include all companies engaged in whole or in part in oil and gas activities. [2] Does not include expenditures for geological and geophysical operations. See also Footnote 3 to Table 75.

P Preliminary; f Forecast.

POOR

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